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Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement, Volume 1, Appendix F

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Volume 1
Appendix F

Nevada Test Site and Oak Ridge Reservation Spent Nuclear Fuel Management Programs

April 1995

U.S. Department of Energy
Office of Environmental Management
Idaho Operations Office

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1. APPENDIX F INTRODUCTION

This appendix addresses the interim storage of spent nuclear fuel (SNF) at two U.S. Department of Energy sites, the Nevada Test Site (NTS) and the Oak Ridge Reservation (ORR). These sites are being considered to provide a reasonable range of alternative settings at which future SNF management activities could be conducted. These locations are not currently involved in management of large quantities of SNF; NTS has none, and ORR has only small quantities. But NTS and ORR do offer experience and infrastructure for the handling, processing and storage of radioactive materials, and they do exemplify a broad spectrum of environmental parameters. This broad spectrum of environmental parameters will provide a perspective on whether and how such location attributes may relate to potential environmental impacts. Consideration of these two sites will permit a programmatic decision to be based upon an assessment of the feasible options without bias to the current storage sites.

This appendix is divided into three parts. Part One is the Appendix F introduction. Part Two contains chapters one through five for the NTS, as well as the NTS references in chapter six and acronyms and abbreviations in Chapter 7. Part Three contains chapters one through five for the ORR, as well as the ORR references in chapter six and abbreviations and acronyms in Chapter 7. A Table of Contents, List of Figures, and List of Tables are included in Parts Two and Three. This approach permitted the inclusion of both sites in one appendix while maintaining chapter numbering consistent with Volume 1 and Appendices A, B, and C.

Currently, no SNF is stored at the NTS and only small quantities of SNF generated by research reactors at ORR are stored there. In order to receive, handle, and store spent nuclear fuel from other DOE sites on an interim basis, new facilities would need to be constructed at the NTS and ORR. Since the basic facilities to receive and handle the spent fuel, as well as any safety-related and emergency containment, cleanup, and recanning facilities, are approximately equivalent for all alternatives being considered, only the size of the storage facility will vary for each alternative, with the Centralization Alternative requiring the largest storage facility. As discussed in Chapter 3, only the Centralization Alternative for spent fuel storage at either the NTS or ORR is analyzed quantitatively in this volume; the Regionalization Alternative is evaluated qualitatively. The results of this appendix are then summarized in Volume 1.

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NEVADA TEST SITE

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1. INTRODUCTION

This part assesses the impacts of construction and operation of proposed spent nuclear fuel (SNF) facilities at the Nevada Test Site (NTS). The NTS is being evaluated for these facilities because of the area available, the isolation of population centers, the apparently suitable site environmental parameters, previous U.S. Department of Energy activities involving radioactive materials at the site, and the planned long-term government control of the site.

This part is organized as follows. Chapter 1 is the introduction, Chapter 2 sets the stage for the area under analysis by providing an overview of the NTS and discussions of the Regulatory Framework and SNF Management Program, and Chapter 3 explains the SNF alternatives being considered at the site.

Chapter 4 describes the human and natural environment that could be affected as a result of the introduction of an SNF facility at the NTS. Environmental parameters such as water resources, socioeconomics, biological resources and air quality are examples of those characterized.

Chapter 5 enumerates the environmental consequences that might be anticipated, the cumulative impacts, the unavoidable adverse impacts, the relationship between short-term use and long-term productivity, the irreversible and irretrievable commitment of resources, and possible mitigation measures that might be anticipated if an SNF facility were built at the NTS. Chapter 6 contains the references used to develop this part of the Environmental Impact Statement. Chapter 7 contains the abbreviations and acronyms used in this Part.

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2. NEVADA TEST SITE BACKGROUND

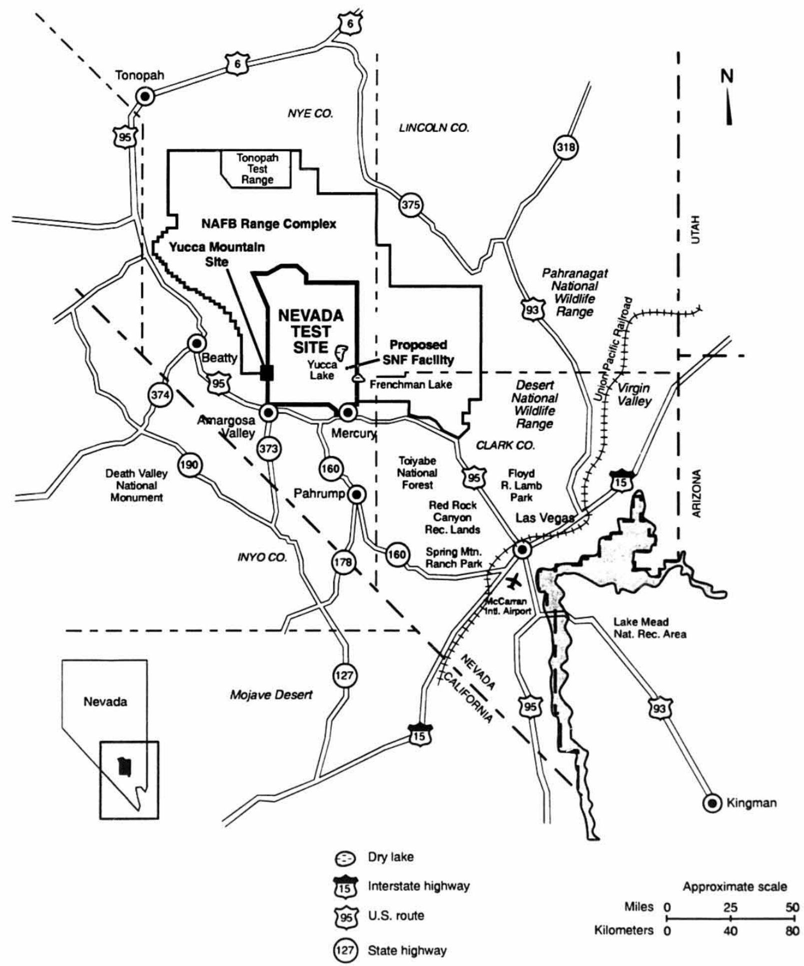
2.1 Overview

2.1.1 Site Description

The Nevada Test Site (NTS), located in the southeastern portion of Nevada, is operated by the U.S. Department of Energy (DOE) as the on-continent test site for nuclear weapons testing. The site encompasses approximately 1,350 square miles (3,500 square kilometers). The NTS is surrounded on the north, east, and west by the Nellis Air Force Base (NAFB) Bombing and Gunnery Range. Together with the Tonopah Test Range, these three properties provide a 15- to 65-mile (24- to 104-kilometer) buffer zone between the test areas and public lands. The Bureau of Land Management owns land on the southern and southwestern borders of the NTS. Las Vegas is approximately 65 miles (104 kilometers) from the southeast corner of the site (Figure 2.1-1) (DOE/NV 1991a; USAF et al. 1991).

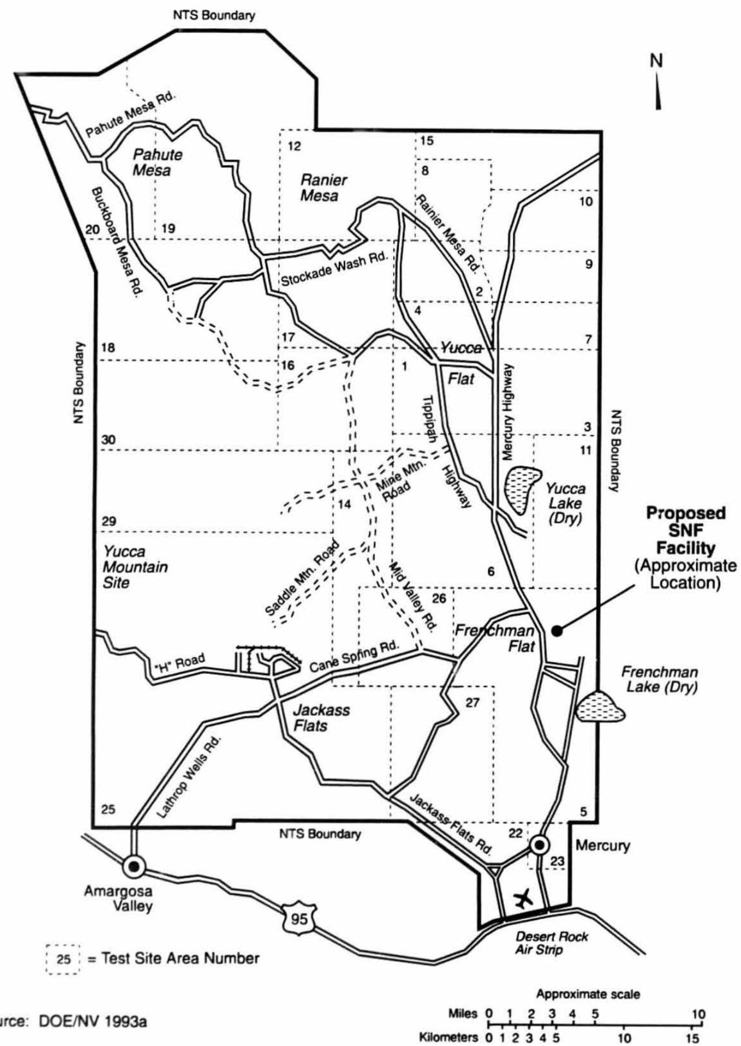
The NTS is a large, open area, tightly controlled, with the infrastructure to conduct tests with hazardous and radioactive materials. Security at the NTS consists of security guards, often using four-wheel drives, patrolling the site. The perimeter of the site is not fenced. Armed guards and electronic security measures are in place for secure areas. Approximately 25 percent of the site is unused or is used as a buffer zone for ongoing programs or projects (DOE/NV 1991a; USAF et al. 1991).

The NTS is broken into numbered test areas to simplify the distribution, use, and control of resources (Figure 2.1-2). Area 22, the site's main entrance, is located on the southeast corner of the site and contains the Desert Rock airstrip. Area 23, adjacent to Area 22, contains the Mercury base camp, which houses administrative operation and general support activities. Offices for the DOE, the U.S. Department of Defense (DoD), Defense Nuclear Agency, Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Sandia National Laboratories (SNL), and all supporting contractors of these organizations are located in this area. Other facilities in this area include the cafeteria, recreation, transportation, and housing. Area 5 (Frenchman Flat) was used in the past for nuclear testing. Area 6, north of



Source: BLM 1990

Figure 2.1-1. Nevada Test Site regional map.



Source: DOE/NV 1993a

Figure 2.1-2. Nevada Test Site map.

Area 5, contains the Control Point One facility which overlooks Yucca Flat, where a large portion of the testing occurs. This facility provides control over and execution of nuclear detonations at the NTS. Also in Area 6 there is a new work camp which is used for construction and craft support. Other areas located on the NTS are the valley of the Yucca Flat (Areas 3, 7, and 9), the Rainier Mesa (Area 12), which is the center of DoD/Defense Nuclear Agency activities, and the Pahute Mesa (Areas 19 and 20) (DOE/NV 1991a; ERDA 1977; USAF et al. 1991). Area 5 will be housing the proposed spent nuclear fuel (SNF) facilities. Figure 2.1-2 shows the approximate location of the proposed SNF facility. The actual location will be determined for site-specific environmental documentation.

2.1.2 Site History

Prior to 1951, the land which is now occupied by the NTS was used for mining and grazing. Primarily, mining was for low grades of copper, lead, silver, gold, mercury, and tungsten. Although there were short periods of mining success at the site, the area was abandoned over time. Grazing ended in 1955 when the Federal government acquired the water and grazing rights of two ranches which were operating on what is now the NTS (ERDA 1977).

Since January 1951, the land now occupied by the NTS has been the primary location for nuclear weapons testing in the United States. Land was withdrawn from the NAFB Bombing and Gunnery Range in 1952 to form the NTS. Subsequent withdrawals occurred in 1958, 1961, and 1962. A Memorandum of Understanding between NAFB and the NTS in 1967 allowed the use of Pahute Mesa by the NTS (DOE/NV 1991a; USAF et al. 1991).

Most of the tests performed at the NTS in the 1950s were atmospheric tests. After 1951, nuclear tests were carried out intermittently until a voluntary moratorium ended testing in October 1958. The first full-scale nuclear detonation occurred in 1957 in a sealed tunnel. Testing resumed in September 1961 following the ending of the moratorium. Atmospheric testing ended in the summer of 1963 following the signing of the Limited Test Ban Treaty. Since 1962, all testing has occurred underground. Two methods have been used for underground testing since 1963: vertical shafts (from the valley of Yucca Flat to the top of Pahute Mesa) and horizontal tunnels (Rainer Mesa) (DOE/NV 1991a; ERDA 1977; USAF et al. 1991).

In addition to underground testing, between 1962 and 1968, earth-cratering tests were conducted as part of the Plowshare Program. This program explored peaceful means of using nuclear explosives. Other tests which have occurred on the NTS have included the Bare Reactor Experiment (1960s) and the open air nuclear reactor, nuclear engine, and nuclear furnace tests (1959-1973). Much of the nuclear testing has been conducted on the NTS by the LANL, LLNL, SNL and, through the Defense Nuclear Agency, the DoD. Non-nuclear testing has included hazardous material spills. Other activities which occur on the NTS are the storage and disposal of low-level radioactive wastes and mixed wastes (DOE/NV 1991a; ERDA 1977; USAF et al. 1991).

As part of DOE's program to establish a national repository for high-level radioactive waste, Lawrence Livermore National Laboratory conducted an evaluation of the effects of radiation and heat from radioactive decay on granite rock formations. The project, known as Spent Fuel Test - Climax, stored 11 spent fuel elements from the Florida Power & Light Company and 6 electric heat simulators in specially designed and constructed holes in the Climax tunnel, located in the northeastern corner of the NTS in Area 15. The SNF, in hermetically sealed canisters, was emplaced in the granite formation, stored for approximately 3 years, retrieved, and then transferred, in 1986, to INEL for further testing (DOE/NV 1983, 1986a).

2.1.3 Nevada Operations Office Mission

The missions of the NTS and/or the DOE Nevada Operations Office include:

- Maintaining the capability to conduct underground nuclear weapons tests.
- Conducting all programs related to nuclear emergencies and threats.
- Supporting arms control, treaty verification, and non/counter proliferation of nuclear weapons technology.
- Supporting research activities as part of being designated a National Environmental Research Park.

- Conducting tests for the Liquefied Gaseous Fuels Spill Testing Program.
- Supporting studies in alternate energy sources and environmental management, research and development, and testing.
- Ensuring that all operations are conducted in compliance with all environmental, safety, and health laws, regulations, standards, agreements, and DOE Orders (DOE/NV 1993b, 1992a, 1991a; ERDA 1977).

2.1.4 Nevada Test Site Management

The DOE Nevada Operations Office is currently administering NTS operations. The NTS has multiple contractor support. The major support contractors are Reynolds Electrical & Engineering Co., Inc., the prime contractor; EG&G Energy Measurements, Inc., the electronic and instrumentation support contractor; Raytheon Services Nevada, the architect-engineering support contractor; and Wackenhut Services, Inc., the site security contractor.

2.1.5 Yucca Mountain Project

The DOE Office of Civilian Waste Management is conducting a program for siting the nation's first geologic repository for spent nuclear fuel and other high-level radioactive wastes. The Yucca Mountain Site has been designated by the U.S. Congress as a candidate site. Although Yucca Mountain is located outside the western boundary of the NTS, a contiguous portion of the NTS has been assigned as part of the potential repository site. Access to the site is accomplished through the NTS and Yucca Mountain Project field offices and support facilities are located in Area 25 (DOE/NV 1993b). Currently, Yucca Mountain is being characterized to study its suitability as a geological repository. The characterization study includes exploratory borings and analyses of meteorological, geological, hydrological, geochemical, erosion, tectonics, and socioeconomics conditions. Upon completion of the characterization study, the Secretary may recommend Yucca Mountain to the U.S. President as viable site for a repository (DOE 1988b).

2.2 Regulatory Framework

The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321-4347, as amended) provides Federal agency decision makers with a process to systematically consider the potential environmental consequences of agency decisions. The DOE has prepared this environmental impact statement (EIS) in conformance with the requirements of this Act to evaluate the potential impacts of programmatic decisions on the management of SNF. This EIS will provide the necessary background, data, and analyses to help decision makers understand the potential environmental consequences of each alternative.

On October 22, 1990, the DOE published a Notice of Intent in the *Federal Register* (FR 1990a) announcing its intent to prepare a programmatic EIS addressing environmental restoration and waste management (including SNF management) activities across the entire DOE Complex. On October 5, 1992, the DOE published a Notice of Intent in the *Federal Register* (FR 1992) announcing its intent to prepare an EIS addressing environmental restoration and waste management and SNF activities at the Idaho National Engineering Laboratory. For further programmatic discussion of this topic, see Volume 1.

Significant Federal and state environmental and nuclear materials management laws are applicable to the NTS. The Federal laws are listed in Volume 1, Section 7.3. The State of Nevada laws are listed alphabetically below:

- Air Pollution Control Law (Title 40 Chapter 445)
- Air Quality Regulations (Title 40 Chapter 445)
- Disposal of Hazardous Waste (Title 40 Chapter 444)
- Disposal of Radioactive Material (Title 40 Chapter 459)
- Facilities for the Management of Hazardous Waste (Title 40 Chapter 444)
- Regulation of Highly Hazardous Substances (Title 40 Chapter 459)
- Solid Waste Disposal Act (Title 40 Chapter 444)
- Storage Tanks (Title 40 Chapter 459)
- Underground Injection Control (Title 40 Chapter 445)

- Water Pollution Control Law (Title 40 Chapter 445)
- Water Pollution Regulations (Title 40 Chapter 445)

2.3 Spent Nuclear Fuel Management Program

Currently, spent nuclear fuel is not generated, received, reprocessed, or stored at the NTS; therefore, a SNF management program does not currently exist for activities at the NTS (DOE 1993). There are no current or foreseeable environmental, safety, or health vulnerabilities at the NTS associated with SNF (DOE 1993). Selection of the No-Action Alternative would not adversely affect the operations or any planned facility modifications at the NTS.

3. SPENT NUCLEAR FUEL ALTERNATIVES

3.1 Description of Management Alternatives

This chapter describes the spent nuclear fuel (SNF) management alternatives evaluated by the U.S. Department of Energy (DOE) for Appendix F that are applicable to the Nevada Test Site (NTS). DOE did not consider the Nevada Test Site to be a preferred site for the management of spent nuclear fuel in the Draft EIS because of the State's current role as the host site for the Yucca Mountain Site Characterization Project. DOE's identification of the preferred alternatives also indicates that DOE does not consider the Nevada Test Site as a preferred site for spent nuclear fuel management in the Final EIS. For the purposes of conducting a thorough NEPA analysis, the NTS provides a contrast to other potential sites because it represents a site that has no existing SNF management infrastructure. The NTS does not currently generate or store any SNF. Hence, of the five alternatives discussed in this Programmatic Environmental Impact Statement (EIS), only two, Regionalization and Centralization, are applicable to the NTS. The other three alternatives -- No Action, Decentralization, and the 1992/1993 Planning Basis -- are not applicable to the NTS since they affect or involve only sites which currently generate or store SNF.

3.1.1 Alternative 1 - No Action

The No Action Alternative is restricted to the minimum actions necessary for the continued safe and secure management of SNF. As defined, this alternative stipulates no SNF shipments to or from DOE facilities. The NTS does not currently generate or store any SNF and would not receive any SNF under this alternative. Therefore, this alternative is not applicable to the NTS and is not analyzed or discussed further in this or subsequent chapters for the NTS.

3.1.2 Alternative 2 - Decentralization

Decentralization involves storage of SNF at or close to generation sites, with limited shipments to the Idaho National Engineering Laboratory (INEL) and Savannah River Site (SRS) as necessary to permit continued operation. Since the NTS does not generate or store any SNF

and would not receive any SNF under this alternative, it is not applicable to the NTS and is not analyzed or discussed further in this or subsequent chapters for the NTS.

3.1.3 Alternative 3 - 1992/1993 Planning Basis

The 1992/1993 Planning Basis Alternative is DOE's documented 1992/1993 plan for the management of DOE and Naval SNF. Since the NTS does not generate or store any SNF and would not receive any SNF under this alternative, it is not applicable to the NTS and is not analyzed or discussed further in this or subsequent chapters for the NTS.

3.1.4 Alternative 4 - Regionalization

3.1.4.1 Overview. The Regionalization Alternative consists of two subalternatives. Subalternative A would distribute existing and new SNF between the Hanford Site, INEL, and SRS by SNF type. Under Subalternative B, SNF would be distributed to either an eastern or western regional site based on geographical location. SNF east of the Mississippi River would be shipped to the eastern region site (i.e., SRS or Oak Ridge Reservation (ORR)). SNF west of the Mississippi River would be shipped to the western regional site (i.e., Hanford, INEL, or NTS). Additionally, all Naval SNF would be shipped to only one of the sites, but not both. The ORR would be the alternative to the SRS as the eastern regional site, and the NTS would be the alternative to both the Hanford Site and INEL as the western regional site.

3.1.4.2 Regionalization Subalternative B. The following fuels would be transported to the NTS for storage under the Regionalization Subalternative B:

- Naval-type SNF (if selected)
  - All, including from the INEL, shipyards, and prototypes
- Hanford Production SNF
  - From western sites including the Hanford Site
- Graphite SNF
  - From western sites including the INEL and Public Service of Colorado

- DOE-Owned Commercial SNF
  - From western sites including the Hanford and INEL
- Experimental - Stainless steel SNF
  - From western sites including the Hanford, INEL, Foreign Research Reactors, and non-DOE domestic research reactors
- Experimental - Zirconium SNF
  - From western sites including the INEL
- Experimental - Other
  - From western sites.
- SRS Production and Aluminum SNF
  - From western sites including INEL, Los Alamos National Laboratory (LANL), Foreign Research Reactors, and non-DOE domestic research reactors

All SNF presently in storage at DOE facilities would arrive at the NTS stabilized and canned to the extent necessary for safe transportation. However, this SNF might need to be uncanned, stabilized, prepared, and recanned at the NTS to ensure safe interim storage. New non-DOE domestic, Foreign Research Reactors, and Naval SNF would be shipped in the state necessary for safe transportation but not necessarily canned. This fuel would be stabilized, prepared, and canned at the NTS to ensure safe interim storage. All fuel would be cooled for a minimum of 120 days prior to shipping and 5 years before being placed in dry storage. Additionally, if the NTS is selected for the Expended Core Facility, Naval SNF would be examined at the NTS before being turned over for interim storage management.

The NTS currently has no facilities that are suitable for receiving, canning, storing, or supporting the research activities necessary for the safe management of SNF. As a result, a new SNF management complex would be built at the NTS under the Regionalization Subalternative B. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility
- Interim dry storage area

- Expended Core Facility similar to the one at the INEL (if selected for Naval Fuel Receipt).

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The technology development facility would investigate the applicability of dry storage technologies and pilot scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. If NTS is selected for Naval fuel receipt, Naval SNF would be examined at the Expended Core Facility prior to being turned over for interim storage management.

The SNF management complex which would be built at the NTS under the Regionalization Alternative would have the same components as that built under the Centralization Alternative. However, the dry storage component would be somewhat smaller due to the smaller SNF inventory that would be transported to the NTS under the Regionalization Alternative. The other components of the SNF management complex would be the same general size as those built under the Centralization Alternative. This is because the inventories of new uncanned fuel which would be sent to the NTS under the Regionalization and Centralization Alternatives would be very similar. Additionally, since the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components, the Regionalization Alternative will not be analyzed separately. This alternative will be compared to the Centralization Alternative in a semiquantitative manner.

If the NTS is not chosen as the western regional site, the Regionalization Alternative would not be applicable to the NTS.

3.1.5 Alternative 5 - Centralization

3.1.5.1 Overview. Under Centralization, all existing and new SNF would be shipped to one site. There are five Centralization options considered in this PEIS; Option A - Hanford Site, Option B - INEL, Option C - SRS, Option D - ORR, Option E - NTS. If the NTS was chosen as the centralization site, all SNF currently stored at the HS, INEL, SRS, ORR, and other sites currently storing DOE fuel would be transferred to the NTS.

3.1.5.2 Centralization Alternative Option E. The following fuels would be transported to the NTS for storage under the Centralization Alternative Option E:

- Naval-type SNF
  - From the INEL and shipyards
- Hanford Production SNF
  - From the Hanford Site
- Graphite SNF
  - From the INEL and Public Service of Colorado
- DOE-Owned Commercial SNF
  - From Hanford, INEL, West Valley Demonstration Project, and B&W Lynchburg
- Experimental - Stainless Steel SNF
  - From Hanford, INEL, SRS, FRR, and non-DOE domestic research reactors
- Experimental - Zirconium SNF
  - From the INEL and SRS
- Experimental - Other
  - From the Oak Ridge National Laboratory (ORNL)
- SRS Production and Aluminum SNF
  - From the INEL, SRS, ORNL, LANL, Brookhaven National Laboratory, Foreign Research Reactors, and non-DOE domestic research reactors.

All SNF presently in storage at DOE facilities would arrive at the NTS stabilized and canned to the extent necessary for safe transportation. However, this SNF may need to be uncanned, stabilized, prepared, and recanned at the NTS to ensure safe interim storage. New non-DOE domestic research reactor, Foreign Research Reactor, and Naval SNF would be shipped in a state necessary for safe transportation but not necessarily canned. This fuel would be stabilized, prepared, and canned at the NTS to ensure safe interim storage. All fuel would be cooled for a minimum of 120 days prior to shipping and 5 years before being placed in dry

storage. Additionally, Naval SNF would be examined at the NTS before being turned over for interim storage management.

The NTS currently has no facilities that are suitable for receiving, canning, storing, or supporting the research activities necessary for the safe management of SNF. As a result, a new SNF management complex would be built at the NTS under the Centralization Alternative Option E. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility
- Interim dry storage area
- Expended Core Facility similar to the one at the INEL.

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The technology development facility would investigate the applicability of dry storage technologies and pilot scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval SNF would be examined at a new Expended Core Facility constructed at the NTS prior to being turned over for interim storage management.

The SNF management complex which would be built at the NTS under the Centralization Alternative would have the same components as those built under the Regionalization Alternative. However, the dry storage component would be somewhat larger under the Centralization Alternative due to the somewhat greater SNF inventory that would be transported to the NTS under this alternative. The other components of the SNF management complex would be the same general size as those built under the Regionalization Alternative. This is because the inventories of new uncanned fuel which would be sent to the NTS under the Regionalization and Centralization Alternatives would be very similar. Additionally, the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components, and would not be significantly different for the two alternatives. Therefore, this alternative will be used as the basis for a semiquantitative comparison with the Regionalization Alternative.

If the NTS is not chosen as the centralization site, the Centralization Alternative would not be applicable to the NTS.

3.2 Comparison of Alternatives

Table 3.2-1 shows a comparison of the alternatives. The Regionalization Alternative column does not include the requirements of the Naval Expended Core Facility, although this facility may be constructed at the site under this alternative. The Centralization Alternative column does include the requirements of the Naval Expended Core Facility, which are presented in Volume 1, Appendix D, since this facility will be built at the site under this alternative.

Table 3.2-1. Comparison of alternatives for the NTS.

Parameter	Regionalization Subalternative B at NTS	Centralization Option E[a]
Land for new facilities (acres)	90	120
Site area (acres)	864,000	864,000
Percent of site area	0.01	0.01
SNF-related employment[b]	556	1,118
Baseline site employment	8,563	8,563
Percent of baseline site employment	6.5	13.1
Estimated cancer fatalities in 80-km population per year, SNF management operations[c]	4.1×10^{-5}	4.1×10^{-5}
Estimated cancer fatalities in 80-km population per year, other site operations	2.6×10^{-6}	2.6×10^{-6}
Estimated probability of cancer fatalities in a maximally exposed individual per year, SNF management operations[c]	5.9×10^{-8}	5.9×10^{-8}
Estimated probability of cancer fatalities in a maximally exposed individual per year, other site operations	5.5×10^{-9}	5.5×10^{-9}
Estimated probability of cancer fatality in average worker per year, SNF management operations[c]	1.6×10^{-5}	1.6×10^{-5}
Estimated maximum probability of cancer fatality in average worker per year, other site operations	2.0×10^{-6}	2.0×10^{-6}
Water use (million gallons) per year, SNF management	3.6	6.1
Baseline water use (million gallons) per year, site operations	1,120	1,120
Percent of baseline site water use	0.32	0.54
Electricity use (megawatt-hours) per year, SNF management	23,000	33,000
Baseline electricity use (megawatt-hours) per year, site operations	183,100	183,100
Percent of baseline site electricity use	12.56	18.02
Sewage discharge (million gallons) per year, SNF management	3.6	6.1
Baseline sewage discharge (million gallons) per year, site operations	0	0

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Table 3.2-1. (continued).

Parameter	Regionalization Subalternative B at NTS	Centralization Option E[a]
Percent of baseline site sewage discharge	NA	NA
High-level waste (cubic meters) per year, SNF management	0	0
Transuranic waste (cubic meters), SNF management	16	16
Mixed waste (cubic meters), SNF management	0	0
Low-level waste (cubic meters), SNF management	203	628
Estimated maximum cancer fatalities in 80-km population from maximum risk accident[d]	6.6×10^{-4}	
Frequency of occurrence (number per year)[d]	1.6×10^{-1}	
Estimated maximum risk of cancer fatalities in 80-km population from maximum risk accident (cancer fatalities per year)[d]	1.1×10^{-4}	
Estimated maximum worker cancer fatalities from maximum risk accident[d]	1.9×10^{-3}	
Frequency of occurrence (number per year)[d]	1.0×10^{-4}	
Estimated maximum risk of worker cancer fatalities from maximum risk accident (cancer fatalities per year)[d]	1.9×10^{-7}	

a. Centralization Option includes the Naval Expended Core Facility results from Volume 1, Appendix D.
b. Annual Average SNF direct construction and operation jobs over the 10-year period 1995 to 2005.
c. Excludes baseline site operations.
d. Centralization Option is the same as the Regionalization Option for the SNF Management Facility and does not include the Naval Expended Core Facility accident analyses results from Volume 1, Appendix D.

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4. AFFECTED ENVIRONMENT

4.1 Overview

This chapter describes the existing environmental conditions in areas potentially affected by a programmatic decision to site spent nuclear fuel (SNF) facilities at the Nevada Test Site (NTS) under the Centralization and Regionalization Alternatives. Topics were selected for analysis based upon their potential to be affected by the alternatives. Each topic is addressed in the detail necessary to serve as a baseline for assessment of potential environmental consequences in Chapter 5.

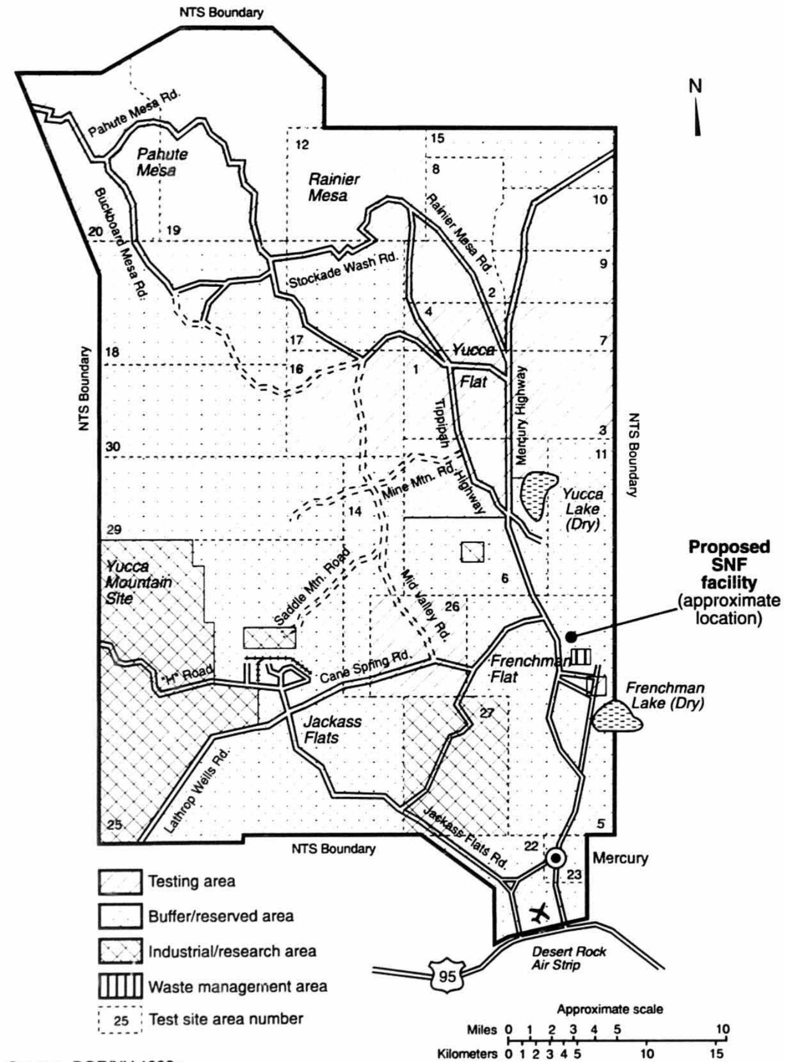
4.2 Land Use

The NTS occupies an area of approximately 1,350 square miles (3,500 square kilometers) in southern Nevada, in a sparsely populated desert area approximately 65 miles (104 kilometers) northwest of Las Vegas. The NTS is almost entirely surrounded by other federally owned lands which buffer it from lands open to the public. The NTS is bordered by the Nellis Air Force Base (NAFB) Bombing and Gunnery Range on the north, east, and west, and by Bureau of Land Management (BLM) lands on the south and southwest (DOE/NV 1993a,b).

Existing land use on the NTS falls into four general categories: Testing Areas; Buffer/Reserved Areas; Industrial/Research Areas; and Waste Management Areas. According to the latest NTS land use map (Figure 4.2-1), approximately 50 percent of the land on the NTS is buffer/reserved area for ongoing programs or projects (DOE/NV 1993a).

Land bordering the site to the north, east, and west is located on the NAFB Bombing and Gunnery Range and is primarily vacant, unused, or used for a buffer zone. Land bordering the site to the south and southwest is owned by the BLM and is used for recreation, grazing, forest management, or wildlife management (DOE/NV 1993a,b).

The NTS is located in an area of sparsely vegetated desert. Beyond the federally owned lands which surround the NTS, principal land uses in Nye County in the vicinity of the NTS



Source: DOE/NV 1993a.

Figure 4.2-1. Land use at the Nevada Test Site.

include mining, grazing, agriculture, and recreation (DOE/NV 1993a). Urban and residential land uses occur beyond the immediate vicinity of the NTS, in fertile valley regions such as the Owens and San Joaquin to the west of the site, the Virgin River to the east of the site, the Pahrump to the south of the site, the Moapa River to the southeast of the site, and the Hiko and Alamo to the northeast of the site (DOE/NV 1993b).

Clark County, to the southeast of the NTS, consists of approximately 7900 square miles (20,220 square kilometers) of which about 95 percent is owned by the federal government (ULI 1992). Primary land uses on these federal lands include grazing, mining, and recreation. The remaining 5 percent of the county supports residential, state and local government, industrial, and retail land uses (Clark County Regional Transportation Commission 1992).

Currently, Nye County does not have a zoning ordinance; therefore, no zoning classification exists for NTS lands. The NTS is required to comply with State of Nevada regulations for air pollution, safety, and transportation, and with Nye County traffic regulations and safety codes (DOE/NV 1993b). Of the total area within Nye County, only a small number of isolated areas are under private ownership and therefore subject to general plan guidelines (NEEDA 1993).

Numerous national, state, and local public recreation areas exist within the NTS region (Figure 2.1-1). Outdoor recreational areas include the Death Valley National Monument, located 12 miles (19 kilometers) to the west/southwest, and the Desert National Wildlife Range, approximately 25 miles (40 kilometers) east. (Portions of the Desert National Wildlife Range are located within NAFB Bombing and Gunnery Range and are as close as 2 miles (3 kilometers) to the NTS). State parks near the site include; the Red Rock Canyon Recreation Lands, approximately 40 miles (64 kilometers) to the southeast; Spring Mountain Ranch State Park, approximately 50 miles (80 kilometers) southeast; and the Floyd R. Lamb State Park, approximately 45 miles (72 kilometers) southeast (BLM 1990).

Other recreational areas include numerous campsites, picnic areas, and sports grounds south of the site in the Toiyabe National Forest, approximately 25 miles (40 kilometers) southeast, and numerous camping and fishing sites north of the site which are used during the spring, summer, and fall months (DOE/NV 1993a,b,c).

The NTS is a controlled area with public access limited to through traffic on U.S. Route 95 and on Lathrop Wells Road (DOE/NV 1993b).

The proposed SNF site is in the northeast portion of Area 5, located in the southeastern part of the NTS. This area is currently designated as the Low-Level Waste Facility Management Area and Buffer/Reserved Area land use categories. This area was also designated as a Non-Nuclear Test Area in the latest NTS Future Land Use Plan (DOE/NV 1993a).

To the east of Area 5, the NTS is bordered by the NAFB Bombing and Gunnery Range, which provides a buffer zone of approximately 50 miles (80 kilometers) between the NTS and lands open to the public. Beyond the NAFB Bombing and Gunnery range land, land uses to the east of the NTS are primarily mining, grazing, and agriculture (BLM 1990; DOE/NV 1993a).

There are no onsite areas that are subject to Native American Treaty rights or contain any prime or unique farmland.

4.3 Socioeconomics

4.3.1 Region of Influence

The socioeconomic information presented in this Programmatic Environmental Impact Statement (PEIS) discusses the baseline conditions in a Region of Influence comprising of Nye and Clark Counties, Nevada. This is the region potentially affected by the principal direct and indirect socioeconomic effects of actions on the NTS. This Region of Influence includes the current residential distribution of the U.S. Department of Energy (DOE) and contractor personnel employed by the NTS, the probable location of offsite contractor operations, and the probable location of labor and capital supporting indirect economic activity linked to the NTS.

The residential distribution of most of the DOE and contractor personnel employed by the NTS reflects existing commuting patterns and attractiveness of area communities. A survey of NTS worker residential distributions in 1988 revealed that 86 percent lived in Clark County and

10 percent in Nye County (DOE 1988a). In Clark County, most NTS employees reside in the Las Vegas vicinity.

The two-county Region of Influence includes several communities located within a driving time of approximately 1 hour from the NTS, including Boulder City and the Las Vegas Valley (includes the "incorporated places" of Henderson, Las Vegas, and North Las Vegas; and the "census-designated places" of East Las Vegas, Enterprise, NAFB Bombing and Gunnery Range, Paradise, Spring Valley, Sunrise Manor and Winchester) in Clark County, and Pahrump and Beatty in Nye County (DOE/NV 1993a,b).

4.3.2 Regional Economic Activity and Population

Regional economic linkage supporting production activity at the NTS occurs primarily with Clark County, where most of the offsite supporting contractors and the labor and capital supporting indirect economic activity linked to the NTS are located.

4.3.2.1 Clark County (Las Vegas Metropolitan Statistical Area[1]). Clark County is composed of five incorporated cities (Las Vegas, Henderson, North Las Vegas, Boulder City, and Mesquite) and large expanses of unincorporated land, some of which are experiencing strong growth. The area experiencing the majority of the county's development is the Las Vegas Valley (ULI 1992). In addition, 95 percent of the total area within the county is owned by the Federal government and includes several state parks, vast stretches of desert, and military installations.

Economic conditions in southern Nevada since the mid-1980s have grown continuously. Economic growth has accelerated relative to national trends due to an expansion in hotel and gaming markets, relocation of retirees to southern Nevada, expansion of local infrastructure, and additional unplanned investment to house new families in the region. The overall long-term growth pattern is forecasted to gradually change the current robust expansion to more stable

[1] At the time of the 1990 census, Clark County and the Las Vegas Metropolitan Statistical Area were synonymous. The Census Bureau subsequently redefined the Las Vegas Metropolitan Statistical Area to include Mohave County, Arizona. However, the numbers provided here reflect the 1990 census definition.

growth conditions, as seen in the United States (The Center for Business and Economic Research 1992).

The economy in the Las Vegas Metropolitan Statistical Area is driven by growth in the hotel and gaming industry. Because of its orientation toward tourism and conventions, the economy is highly service oriented. Service employment in the Las Vegas area is substantially higher than the relative national share, accounting for nearly 45 percent of total employment, with hotels and gaming accounting for approximately 30 percent of the service factor. Trade employment accounts for 21 percent, and government and construction each account for an additional 10 percent (ULI 1992). Construction employment has increased over 130 percent since 1980, with 32,000 jobs in that sector in 1993 particularly due to the building and expansion of a number of casinos in Clark County (DOE/NV 1993a). The industrial market has also induced growth in the construction sector, causing a 50 percent increase in new construction activity between 1990 and 1992. Growth in the industrial market is expected to continue, with demand outpacing new construction (ULI 1992). Manufacturing employment is increasing steadily (7 percent from 1992 to 1993); however, this sector comprises only a 2.8 percent share of total employment (DOE/NV 1993a), still well below the national average.

Between 1980 and 1990, Clark County added an average of 15,000 jobs per year. By year-end 1991 another 19,000 jobs had been added to the employment base for 1990, for a total of 388,000 jobs (ULI 1992). In September 1992, employment in the Las Vegas area reached 399,900. Despite the national recession during 1990-1992, the number of existing jobs in the Las Vegas area increased rapidly, averaging an 8.1 percent gain during that period (DOE/NV 1993a).

The number of existing jobs in the Las Vegas area is projected to continue increasing for the next several years. The State of Nevada Employment Security Research Department estimated there would be a total of 125,190 new jobs in the Las Vegas area between 1991 and 1996, an increase of approximately 6 percent annually (DOE/NV 1993a).

The unemployment rate reached a low of 4.9 percent in 1990 and increased to 7.5 percent as of June 1993 (DOE/NV 1993a). The increase in unemployment reflected the fact that the in-migration of labor exceeded the growth in employment opportunities. However, the unemployment level is expected to decrease with new hotel, gaming, and amusement properties opening at the end of 1993 (DOE/NV 1993a).

Most of the population in the Las Vegas Metropolitan Statistical Area is centered in the Las Vegas Valley, with six population groupings in the area: the Las Vegas Valley, Boulder City, Indian Springs, Laughlin, Mesquite, and the Moapa Valley (DOE/NV 1993b). In 1990, the population of the metropolitan statistical area totaled 735,000, growing at a rate of 4.7 percent annually from 1980 (ULI 1992). This rate of growth, however, is lower than that near the end of the 1980s. The population of the metropolitan statistical area was estimated at over 900,000 as of August 1993, an increase of nearly 8 percent annually since 1990 (DOE/NV 1993b).

4.3.2.2 Nye County. The employment level in Nye County (11,310 jobs) is low relative to Clark County, and includes opportunities in the services, mining, and government sectors (DOE/NV 1993b).

Nye County is sparsely populated, with the two largest population groupings being in the unincorporated communities of Pahrump and Tonopah. The populations of Pahrump and Tonopah in 1990 were 7,424 and 3,616 (62 percent and 20 percent of the county total), respectively (DOE/NV 1993b).

Tourist (and business traveller) activity is an important part of the Nye County economy in communities along U.S. Route 95; however, in each community, mining is the major, even dominant, economic force.

In the 1970s and 1980s, nuclear weapons testing at the NTS dominated the Nye County economy when described in terms of employment by place of work. Most of the NTS work force commutes to Mercury or forward areas from the Las Vegas Valley, and most food and other services are provided at federally subsidized facilities onsite. However, some Nye County businesses do provide NTS support services. In the context of the Yucca Mountain repository oversight program, Nye County and DOE have engaged in efforts that could lead to greater employment and procurement opportunities for Nye County residents and businesses (NEEDA 1993).

4.3.2.3 Nevada Test Site. The NTS work force supports engineering design, construction, and operation of the site and includes people employed by DOE and people employed by DOE contractors. The total NTS work force in 1993 included nearly 4,000 jobs located at the NTS and an additional 5,000 jobs in the Nevada Operations Office (DOE/NV 1993a). As of January 1994, the work force totaled 8,563 (3,286 on NTS, 3,805 in Las Vegas, and 1,472 in the rest of Nevada or other areas). There is currently no SNF-related employment at NTS (DOE/NV 1994a).

4.3.2.4 Aggregate Regional Economic and Demographic Baseline. For the purposes of establishing a regional baseline to assess potential impacts for the programmatic analyses in Section 5.3, regional economic and demographic data for Clark and Nye counties were aggregated to form one region (Table 4.3-1).

The total population of this Region of Influence is projected to be 998,093 persons in 1995 and to grow at an annual average rate of 2.7 percent, reaching 1,281,666 persons in 2004. The labor force of the Region of Influence is projected to grow at an annual average rate of 3.1 percent, reaching 792,309 persons in 2004. The total employment in the Region of Influence is projected to grow at an annual average rate of approximately 3.1 percent from 552,439 jobs in 1995 to 734,589 jobs in 2004.

4.3.3 Public Service, Education and Training, and Housing Infrastructure

4.3.3.1 Police and Fire. The NTS's fire protection capacity is structured to accommodate current mission requirements, with a self-contained firefighting department responsible for suppression and prevention. Other services include rescue, hazardous material response, training of fire personnel, fire prevention inspections, installation of all fire extinguishers at the NTS, and fire prevention awareness programs. In addition, the DOE has signed an agreement whereby the Nye County Fire Department will assist the Clark County Fire Department in case of an emergency at the NTS (DOE/NV 1993a).

The Las Vegas Fire Department is spending $9.7 million to build three new fire stations in the northwest area of the city to support growing public service demand in this area. The Clark

Table 4.3-1. Aggregate regional economic and demographic indicators for the NTS.[a]

Years	Regional employment	Regional labor force	Regional population
1995	552,439	595,851	998,093
1996	573,279	618,329	1,033,234
1997	594,916	691,666	1,069,422
1998	617,450	665,968	1,107,037
1999	640,822	691,175	1,145,711
2000	665,060	717,317	1,185,766
2001	681,956	735,538	1,209,316
2002	699,258	754,197	1,233,372
2003	716,971	773,299	1,257,672
2004	734,589	792,309	1,281,666
2005	752,356	811,483	1,305,461
Average Annual Growth Rate	3.1%	3.1%	2.7%

a. Sources: Nye County Board of Commissioners (1993); The Center for Business and Economic Research (1992).

Note: Aggregate region includes Clark and Nye Counties. Labor force projection developed for this study.

County Fire Department plans to add two new fire departments within the next 5 years. There is a mutual agreement between the Clark County Fire Department and all surrounding area departments to assist in any fire emergency when necessary (DOE/NV 1993a).

Law enforcement at the NTS is provided by the Nye County Sheriff. Security enforcement, established to accommodate the requirements of NTS's mission, is the responsibility of a private contractor. Regional law enforcement services are provided principally by the Las Vegas Metropolitan Police Department. Las Vegas ranks fourth nationally in metropolitan statistical areas in police per capita, with 1 per 277 population (DOE/NV 1993a).

4.3.3.2 Health Care. The NTS has a self-contained medical center that provides limited emergency treatment. Health care in the Las Vegas metropolitan area is provided through 13 full-service hospitals, with 3.44 hospital beds per 1,000 population. A major proposed health care facility is scheduled to open in 1994 to accommodate demand (DOE/NV 1993a).

4.3.3.3 Education and Training. The Clark County School District provides education services for the families of the majority of the employees who work at the NTS. Enrollment in the Clark County School District was approximately 122,000 student in 1992 and was projected to be 136,000 students in 1993. An average student/teacher ratio of 22.32 is reported for elementary school grades K-6; the student/teacher ratio is not reported for other grades (DOE/NV 1993a).

Higher education and training resources provided by the NTS include the support provided by the DOE Contractor Education and Training Departments, with technical training in areas such as Radiation Protection Training, Radiological Response Training, Environmental and Health Training (which includes Hazardous Waste, Site Operation, and Emergency Response) to support NTS's mission. In addition, there are a number of vocational, training, and higher education institutions in the Las Vegas metropolitan area (DOE/NV 1993a).

Since 1990, southern Nevada has experienced tremendous growth in school enrollment. To accommodate the influx of students, the school district was able to negotiate the largest bond sale in Nevada history along with regular allocations from the Nevada legislature (DOE/NV 1993a).

4.3.3.4 Housing. Between 1980 and 1990, the number of housing units in Clark County increased by 84 percent, from approximately 174,000 to approximately 320,500. The housing market continues to flourish, as the demand for new housing has consistently exceeded the supply (ULI 1992). The increase in demand is attributable to the influx of retirees and other in-migrant population.

Residential building permits, which peaked in 1988 at 26,400 units, declined to 13,500 units in 1991. Between 1991 and 1995, the number of permits issued is expected to average 15,000 units per year (ULI 1992). Demand is projected to outpace supply over the next 5 years, given the strong projections for population and employment (ULI 1992).

4.4 Cultural Resources

4.4.1 Archaeological Sites and Historic Structures

For approximately 12,000 years, people have inhabited the lands now comprising the NTS site. The availability of surface water was the primary determinant governing the location of past human occupation on these lands. On what is now the NTS, access to surface water was through springs located in canyons and at the bases of mountains and mesas. Therefore, there is very little evidence of human occupation in valleys or playas where surface water sources were unavailable, including the Frenchman Flat area where the proposed SNF site would be located (DOE/NV 1993b).

Three cultural resource surveys were conducted in the vicinity of the proposed site. Two archaeological sites were recorded but neither was considered potentially eligible for listing on the National Register of Historic Places (DRI 1991, 1989, 1987). As a result, no prehistoric or historic resources are expected to be located on the proposed SNF site.

4.4.2 Native American Resources

The Southern Paiute and Shoshone Native American tribes are known to have inhabited southern Nevada including parts of what is now the NTS. These tribes are known to be affiliated

with sites located in the northern portions of NTS including the Pahute and Rainier Mesas. However, no known Native American resources are located within the proposed SNF site (DRI 1986a).

4.4.3 Paleontological Resources

The NTS is characterized by alluvium-filled, topographically closed valleys surrounded by ranges composed of Paleozoic sedimentary rocks and Tertiary volcanic tuffs and lavas. Although igneous rocks do not contain fossils, the deposits might contain late Pleistocene terrestrial vertebrate fossils (Sandia National Laboratories 1982).

4.5 Aesthetics and Scenic Resources

Visual or scenic resources comprise the natural and manmade features that give a particular environment its aesthetic qualities. These features form the overall impression that a viewer receives of an area or its landscape character.

Scenic resources at the NTS are set in a landscape which is a transition area between the Mojave Desert and the Great Basin, with vegetation ranging from grasses and creosote bush in the lower elevations to juniper, pinyon pine and sagebrush in elevations above 5,000 feet (1,524 meters) (DOE/NV 1993b). The topography of the NTS consists of a series of mountain ranges arranged in a north-south orientation separated by broad valleys (DOE/NV 1993b). The topography is also characterized by the presence of numerous craters produced by past nuclear testing at the NTS. Of the three principal valleys located within the NTS, Frenchman Flat surrounds the proposed location of the SNF site (BLM 1990). Access to the NTS is from U.S. Route 95, which runs in an east-west direction along the south side of the NTS at Mercury Valley (BLM 1990). The Mercury Highway, which runs north from the Mercury Base Camp, is a restricted access road that is not available for public access (Figure 2.1-2).

The proposed SNF site at the NTS is set along the east side of the Mercury Highway in Area 5, within the Frenchman Flat. The proposed SNF site is located in the vicinity of the existing Radioactive Waste Management Site. The land cover in this area is typical desert vegetation.

The viewshed surrounding the NTS consists of unpopulated to sparsely populated desert and rural lands. Since the NTS is surrounded to the east, north and west by the NAFB Bombing and Gunnery Range and to the south by lands controlled by the BLM, the only public views into the interior of the NTS are from U.S. Route 95. Since the southern boundary of the NTS is ringed by various mountain ranges, including the Spector Range, Striped Hills, Red Mountain, and the Spotted Range, views to the interior of the site are generally limited to the Mercury Valley and the Mercury Base Camp (BLM 1990).

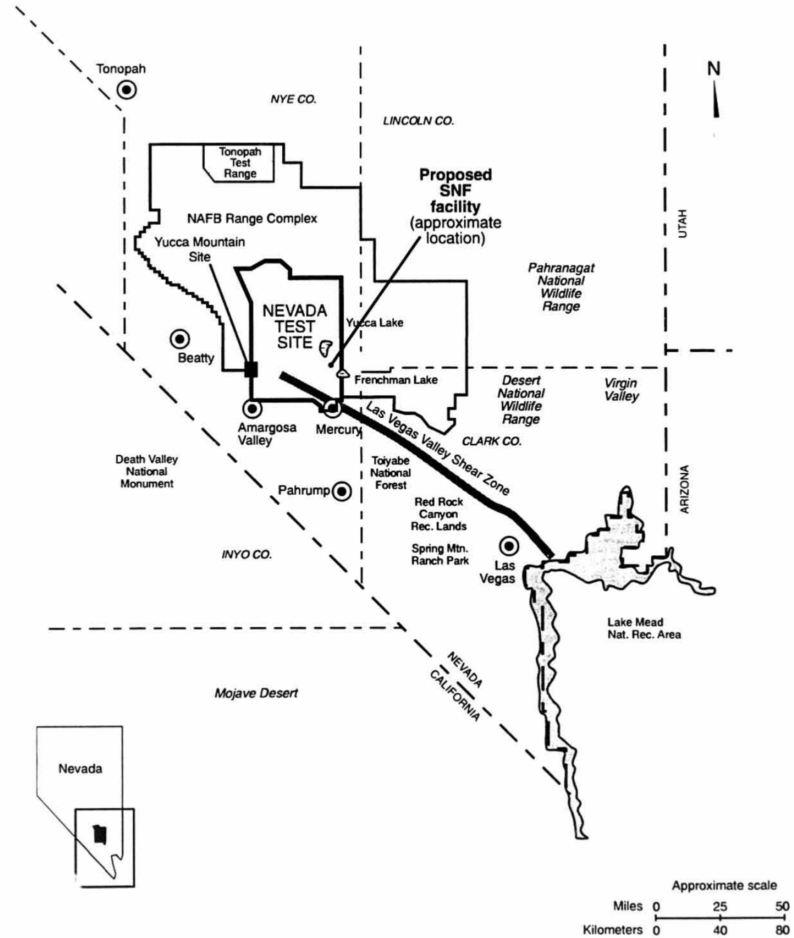
Low sensitivity exists when the public can be expected to have little or no concern about changes in the landscape. Little value may be ascribed to the views, or they may be similar to others in the area. In general, due to the mixture of industrial uses, open desert, and restricted access, the NTS could be classified as having low visual sensitivity.

4.6 Geologic Resources

This section provides a description of the general geology, geologic resources, and seismic and volcanic hazards at the NTS and surrounding area. This section also describes any existing impacts to the geology and geologic resources that have resulted from past and present activities conducted at the NTS.

4.6.1 General Geology

As shown on Figure 4.6-1, the NTS is located east and north of the Walker Lane–Las Vegas Valley Shear Zone (Eckel 1968). Walker Lane is a northwest-trending belt of right-lateral faults that disrupts the regional structural grain in the southwestern part of the Great Basin along the California-Nevada border. The Las Vegas Valley shear zone is a concealed zone of right-lateral faulting along the north side of the Las Vegas Valley (DOE 1988b). Whether the Walker Lane-Las Vegas Valley Shear Zone comprises a continuous single fault or two faults is debatable. Most geologists consider it to be a single fault system, which in the NTS area is buried beneath



Sources: Eckel 1968; DOE 1988b.

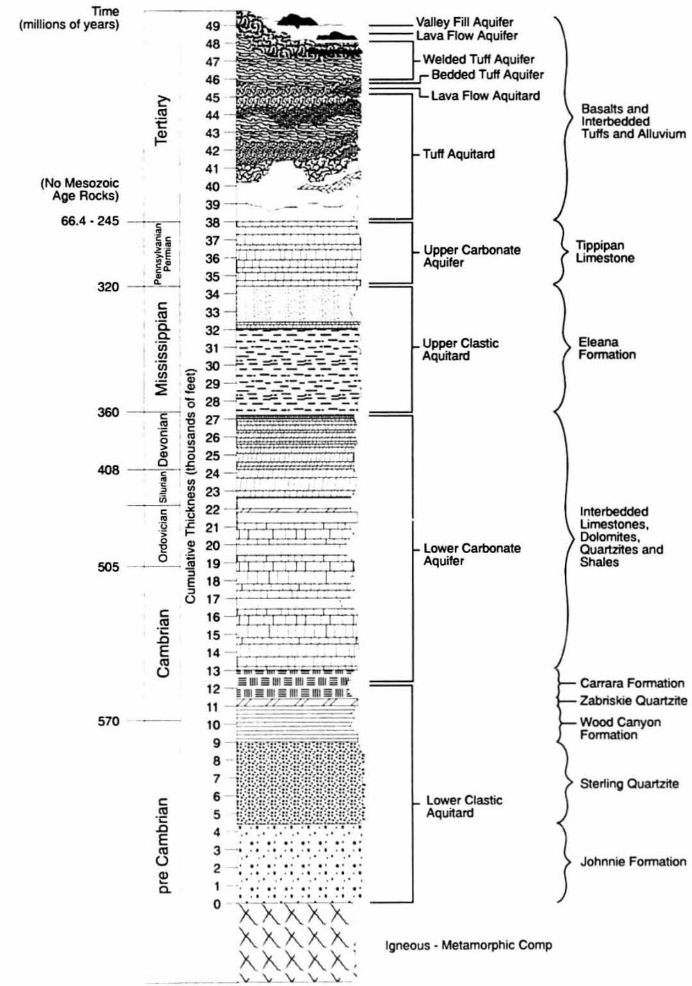
Figure 4.6-1. Location of Nevada Test Site in relation to regional fault zones.

thick Tertiary strata (Eckel 1968). The NTS also lies in the southern part of the Great Basin Section of the Basin and Range Physiographic Province. The local geology of the NTS is characterized by mountain ranges composed of Precambrian and Paleozoic sedimentary rocks and Tertiary volcanic tuffs and lavas that surround alluvium-filled, topographically closed valleys. A generalized stratigraphic column of the area is shown on Figure 4.6-2 (Sandia National Laboratory 1982). Figure 4.6-2 also shows the six aquifers and four aquitards of the NTS area (see Section 4.8). A schematic cross section illustrating NTS geology is shown on Figure 4.6-3 (DOE 1986). A geologic map of the NTS is shown as Figure 4.6-4 (DOE/NV 1993b).

The sedimentary rocks are complexly folded and faulted and are comprised mainly of carbonates (dolomite and limestone) in the upper and lower parts of the column and clastics (shale and sandstone) in the middle section. Above the approximately 4,000 meters (13,000 feet) of Precambrian to Cambrian clastic deposits are approximately 4,300 meters (14,000 feet) of Cambrian through Devonian carbonates, 2,400 meters (8,000 feet) of Mississippian shales and sandstones, and 900 meters (3,000 feet) of Pennsylvanian to Permian limestones (Sandia National Laboratory 1982).

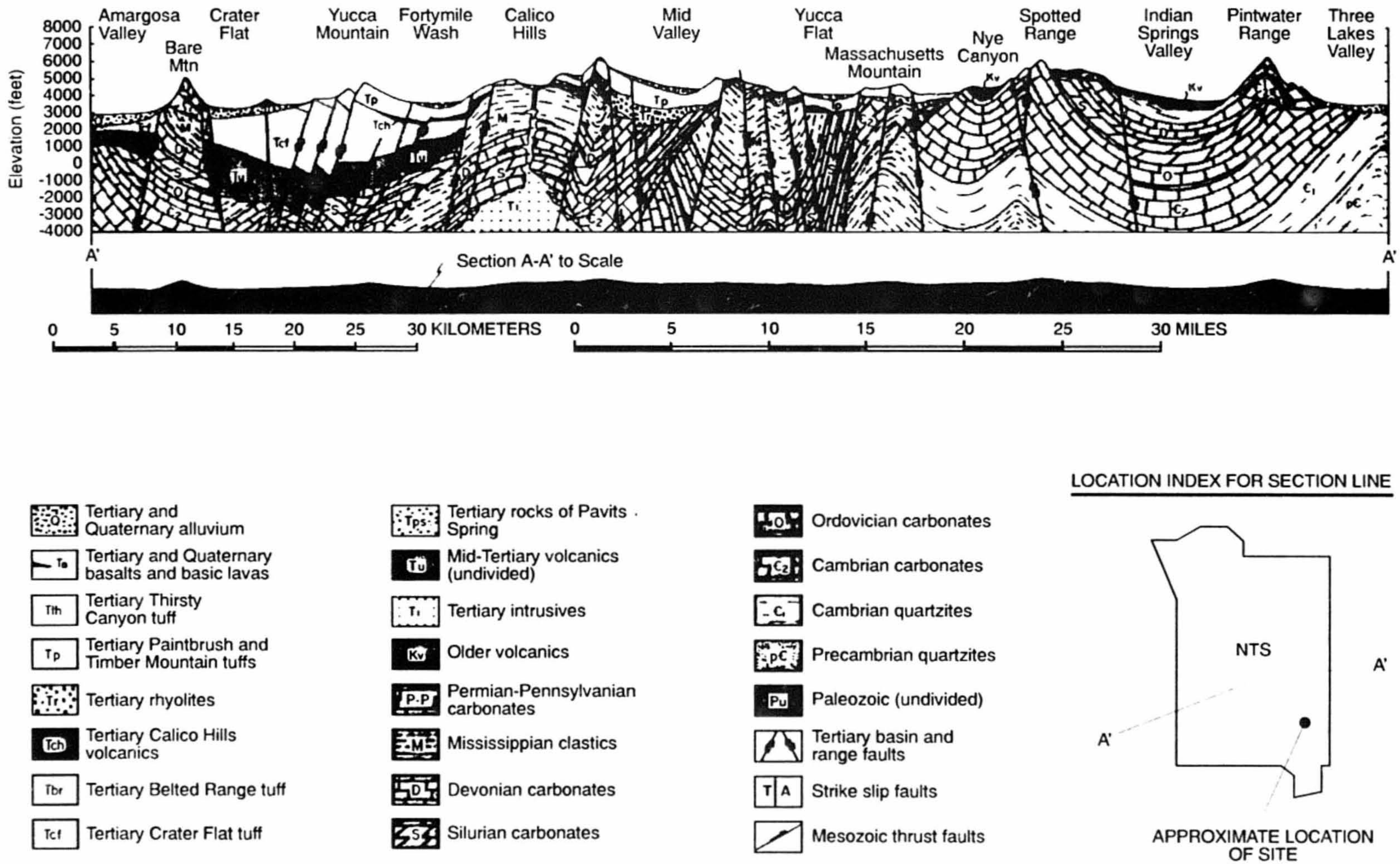
The volcanic rocks in the NTS area are predominantly Tertiary tuffs that are high in silica. Although there are minor amounts of Tertiary basalts and a few scattered Mesozoic granitic plutons in the area (Sandia National Laboratory 1982), the Tertiary tuffs comprise approximately 70 percent of the rocks exposed at the surface (Eckel 1968).

The valleys formed between steeply dipping faults that have become filled with alluvium and comprise approximately 30 percent of the area (Eckel 1968). This generally unconsolidated alluvium is derived from erosion of nearby hills composed of Tertiary and Paleozoic rocks and ranges in thickness from 600 to 900 meters (2,000 to 3,000 feet) (DOE/NV 1992c). Some layers are cemented by calcium carbonate (caliche) and/or clays. The alluvial materials are better sorted and finer grained toward the center of the basins. The sediments in the playas (flat-floored undrained desert basins that, at times, become shallow lakes) consist of very fine-grained lacustrine deposits up to several tens of meters (feet) thick. Near the range fronts, alluvium is generally composed of angular rubble, with individual clasts commonly a foot or more in diameter surrounded by a matrix of silt, sand, and gravel (Sandia National Laboratory 1982).



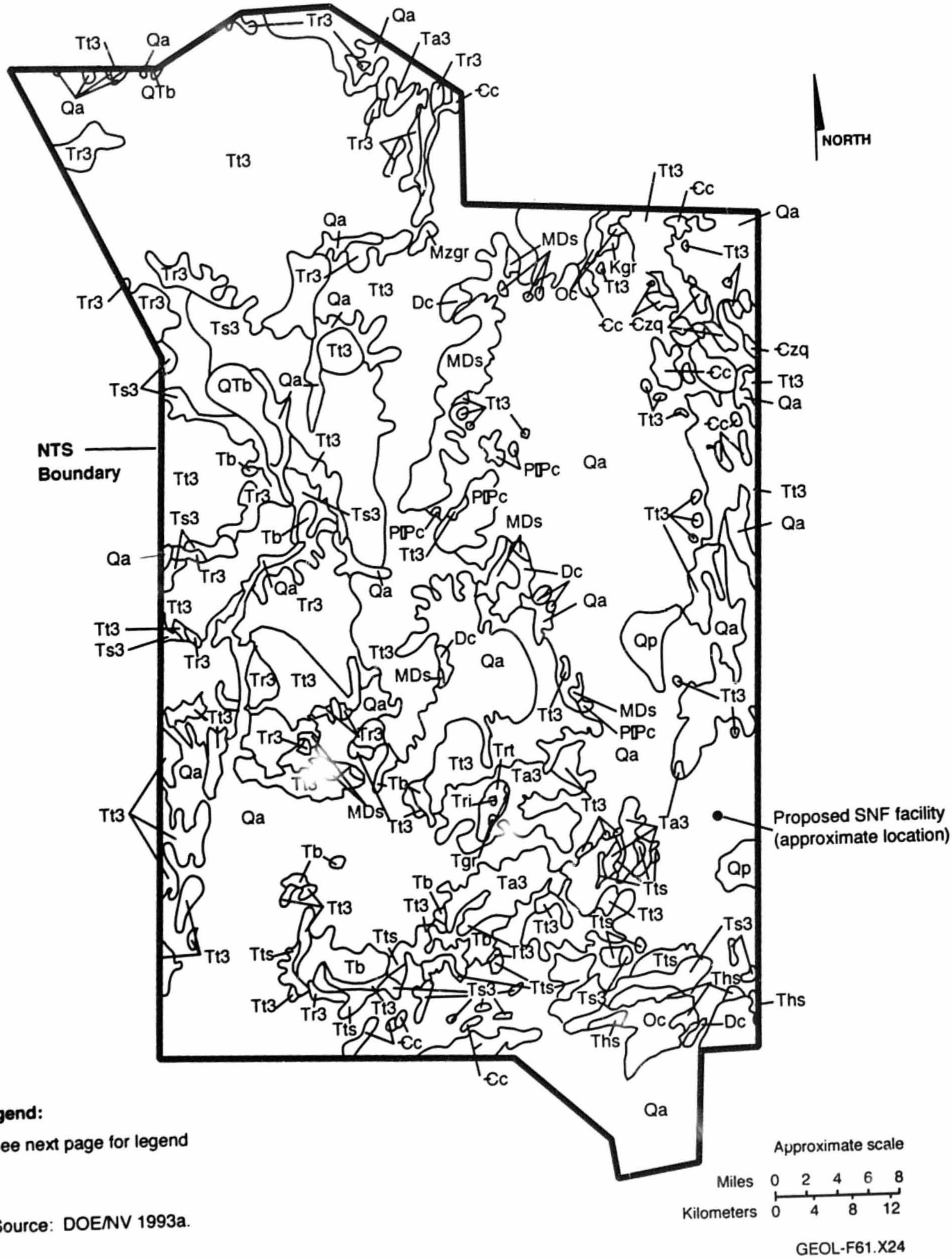
Source: Sandia National Laboratory 1982.

Figure 4.6-2. Stratigraphic column of the Nevada Test Site.



Source: DOE 1986.

Figure 4.6-3. Schematic cross section portraying the geologic complexity of NTS.



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Source: DOE/NV 1993a.

Figure 4.6-4. Geologic map of the NTS.

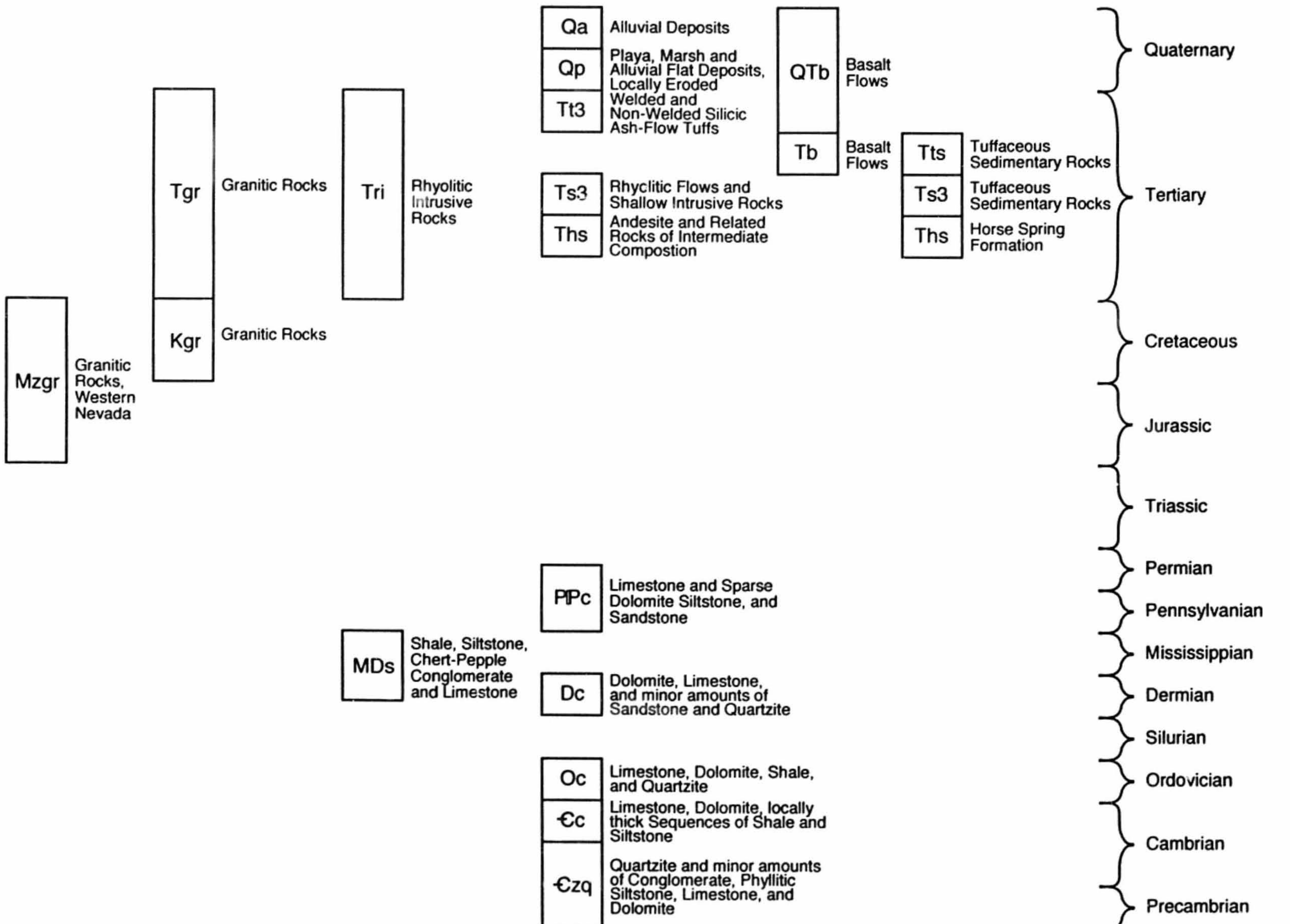


Figure 4.6-4. Geologic map of the NTS (continued).

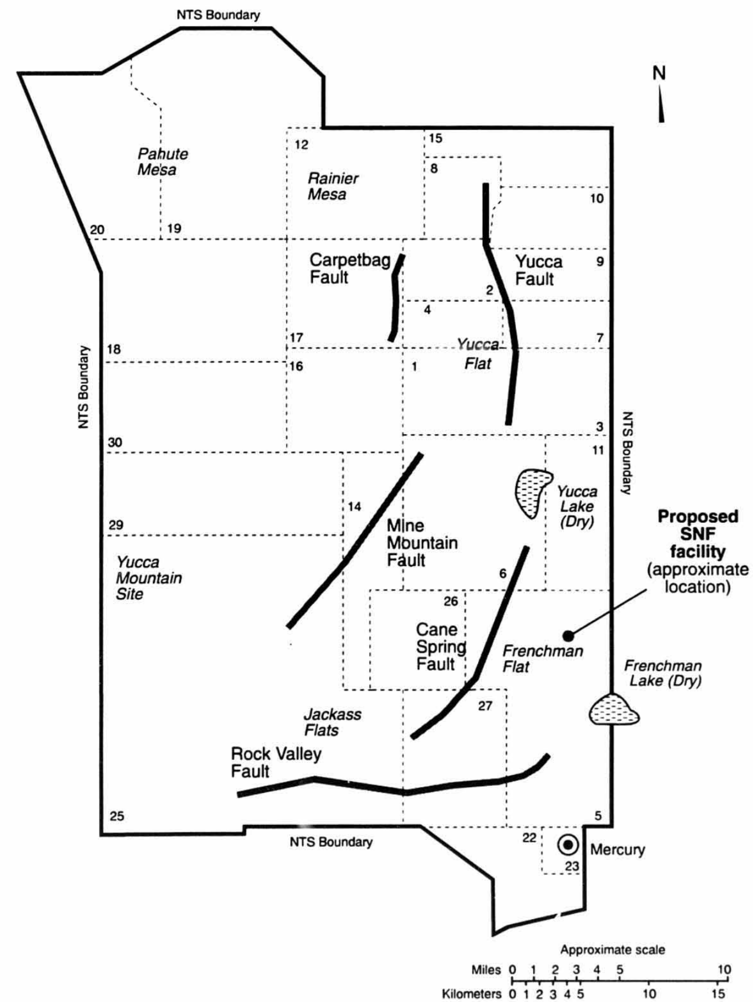
Faulting in the NTS area generally occurs as thrust faults (faults having shallow inclinations, mostly between 10 and 20 degrees), normal faults (faults with downward displacement of the face of the rock that lies above the fault), and strike-slip faults (nearly vertical faults characterized by shear zones) (DOE/NV 1992c). The faults located at NTS are shown on Figure 4.6-5 (DOE/NV 1993b). Thrust faulting in the NTS area occurs as three major thrust faults, with the total displacement along this fault system ranging from 40 to 48 kilometers (25 to 30 miles). Normal faults in the NTS area exist in both ranges and valleys and generally strike northeast and northwest, while a set of younger and potentially active faults strike north. The nearest strike-slip structure to the NTS is the Walker Lane-Las Vegas Valley Shear Zone (see Figure 4.6-1). Estimates of horizontal displacement along this shear zone range from 40 to 160 kilometers (25 to 100 miles) (Sandia National Laboratory 1982).

At the NTS, recent displacement has occurred along several faults as a consequence of underground nuclear explosions. This displacement is not attributable to naturally occurring seismic activity. Fault displacements are thought to have occurred as a result of the added stress produced by the explosion, the vibrations produced by the explosions, or a combination of both (Eckel 1968).

Faults are designated as capable if they have exhibited movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years (CFR 1993a). Almost all of the natural fault movement in the NTS area occurred several million years ago. However, movement along Yucca Fault, a north-south striking fault known in the northeast portion of the NTS (see Figure 4.6-5), is believed to have occurred sometime during the last tens of thousands to 250,000 years (Leedom 1994; Sandia National Laboratory 1982). Given the broad range of time during which displacement along Yucca Fault is believed to have occurred, Yucca Fault may or may not be an NRC capable fault (Leedom 1994).

4.6.2 Geologic Resources

Gold, tungsten, and molybdenum may exist in carbonate rocks near igneous intrusions, regional thrust faults, or other faults at the NTS. In other areas, these deposits have been found



Source: DOE/NV 1993b.

Figure 4.6-5. Approximate location of proposed facility in relation to major faults at NTS.

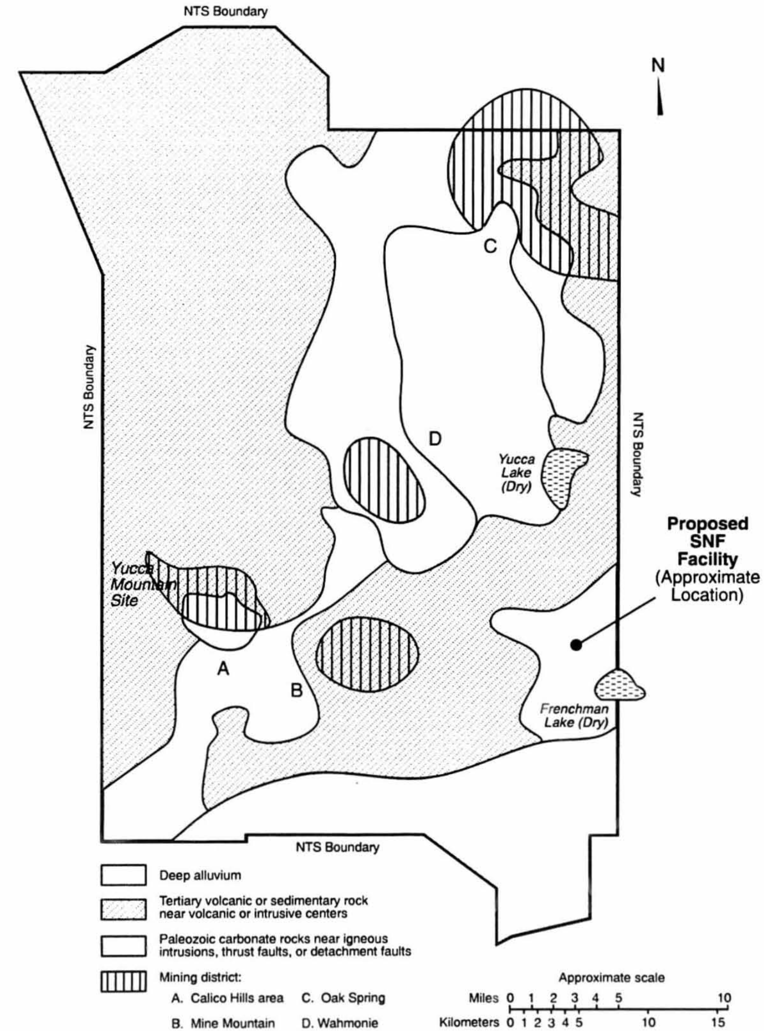
in carbonate rocks associated with this type of terrane. However, based on available information, the NTS is assessed as having only a low to moderate potential for the occurrence of tungsten skarn (contact metamorphic rock rich in iron) deposits and/or polymetallic replacement deposits, and very low potential for the discovery of gold in these types of rocks. Magnetite deposits exist in rocks at the NTS, but they are not extensive and have very low resource potential. Figure 4.6-6 shows the possible location of the SNF storage facility in relation to the types of terrains associated with geologic resources as well as to locations of mining districts (USAF et al. 1991).

Gold and silver may exist at NTS in Tertiary volcanic rocks or in sedimentary rocks near volcanic or intrusive centers. Based on limited information, however, NTS is assessed as having a low to moderate potential for the development of precious metal deposits in these rocks. It is estimated that one small to medium-sized precious metals deposit might have been developed within the NTS had the area remained open to mineral development (USAF et al. 1991).

Much of the alluvial areas along the lower flanks of the ranges within the NTS contain sand and gravel reserves. These materials, however, do not have any unique value over similar material occurring in other areas throughout southern Nevada (USAF et al. 1991).

Zeolitized rocks (various hydrous silicates occurring as secondary minerals in cavities of lavas) underlie most of the volcanic rocks and the alluvial basins at the NTS. Clinoptilolite and mordenite, either alone or in mixtures, are the most common zeolites in these deposits, but ferrierite, chabazite, and analcime also occur. Zeolite deposits in Nevada that have been developed for exploitation are lakebed deposits that have been altered to zeolites under saline water-saturated conditions. Zeolites are used in water softeners, detergent builders, and cracking catalysts. Very little information is available on the tonnage and grade of these deposits. The widespread occurrence of zeolite deposits, however, requires that the deposits at NTS be assigned a low to moderate potential for development (USAF et al. 1991).

Barite is also known to occur at the NTS. The barite occurs in veins associated with quartz and mercury, antimony, and lead mineralization. These veins cut Devonian carbonate rocks. However, the barite veins at the NTS are small and impure, and do not represent a potential barite resource (USAF et al. 1991).



Source: USAF et al. 1991.

Figure 4.6-6. Geologic terrains and mining districts of the Nevada Test Site.

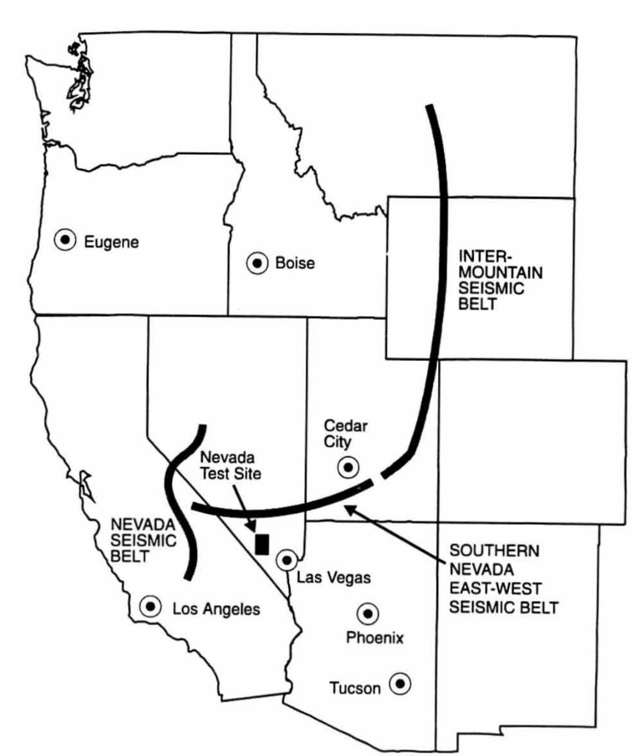
Fluorite is also reported to be present at the NTS, occurring in veins and replacement bodies within Paleozoic sedimentary rock. However, little is known about this occurrence; therefore, the NTS is assumed to have a very low to moderate potential for the development of fluorite resources (USAF et al. 1991).

4.6.3 Seismic and Volcanic Hazards

The NTS lies on the southern margin of the Southern Nevada East-West Seismic Belt. This belt connects the north-trending Nevada Seismic Belt, about 160 kilometers (100 miles) west of the site with the north-trending Intermountain Seismic Belt about 240 kilometers (150 miles) to the east. The location of these seismic belts are shown on Figure 4.6-7. The pattern of historic earthquakes in the western United States is marked by relatively brief episodes of intense activity in areas that may have been relatively inactive for hundreds and perhaps thousands of years (DOE 1986).

The southern Nevada region is generally characterized as an area of moderate seismic activity (DOE/NV 1993b). The proposed SNF management site is located on the eastern NTS in a region considered to have a moderate seismic-activity level. Earthquakes in southern California and the California desert have registered on the NTS seismic network.

Prior to the installation of a seismic network within a 160-kilometer (100-mile) radius of the site in 1978 and 1979, 12 earthquakes (including one series of earthquakes) with Richter magnitudes (M) of equal to or greater than 6.5 were reported within a 400-kilometer (250-mile) radius of the site (DOE/NV 1994b). One of the largest and nearest of the earthquakes relative to NTS was the 1872 Owens Valley shock (M = 8.25), located approximately 150 kilometers (100 miles) from the site. Figure 4.6-8 shows the location of the pre-network earthquakes with M greater than or equal to 5 that have occurred near the NTS (DOE 1988b). Recorded seismic activity prior to 1978 in the vicinity of the NTS also includes two earthquakes with M equals 4.3 and M equals 4.5 near Massachusetts Mountain (located just north of the proposed SNF storage site) and in Frenchman Flat (located in the southeast corner of the NTS, an area that includes the proposed SNF storage site) (DOE/NV 1994b).

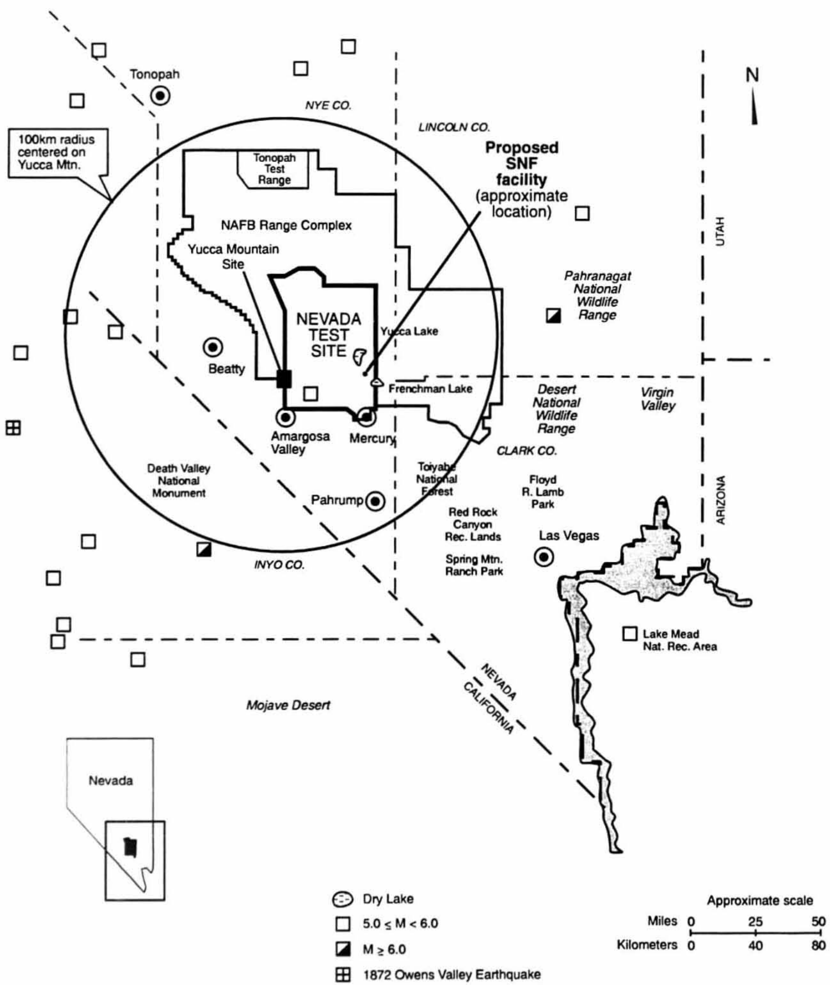


Sources: DOE 1986 and DOE/NV 1993b.

Approximate scale

Miles	0	115	230
Kilometers	0	185	370

Figure 4.6-7. Location of the NTS in relation to the Nevada Seismic Belt, the Intermountain Seismic Belt, and the Southern Nevada East-West Seismic Belt.



Source: DOE 1988b; DOE/NV 1994b.

Figure 4.6-8. Historical Seismicity of the Southern Great Basin from 1868 through 1993 for M>5.

Between 1978 and 1981, no earthquakes with magnitudes greater than 4.3 were recorded. Since 1981, a magnitude 5.6 earthquake was recorded near Little Skull Mountain (located near the southwest corner of the NTS) in 1992 at a depth of 12 kilometers (7.5 miles). In 1993, a magnitude 3.5 earthquake was recorded southeast of the town of Mercury on the NTS (DOE/NV 1994b). However, there is some uncertainty in the seismic sources for many signals recorded by the seismic monitoring network in the area, because underground nuclear explosions, surface drilling, and explosions to support geophysical investigations may produce earthquake-like signals (DOE 1986).

The most probable source for seismic activity within the area where the SNF storage facility would be located is the Cane Spring Fault (see Figure 4.6-5). This fault is thought to be the source of the magnitude 4.3 Massachusetts Mountain earthquake discussed above. The maximum credible earthquake associated with the Cane Springs Fault is expected to be a magnitude earthquake of 6.7. The recurrence interval for this magnitude earthquake is estimated at 10,000 to 30,000 years (DOE/NV 1993a).

Predictions of future seismicity and faulting, however, are complicated by a number of factors. Because the recurrence interval for large earthquakes on a Basin and Range fault may be thousands of years, epicenter maps of historic earthquakes or evidence of Holocene faulting alone may not be reliable indicators of future or long-term seismicity. Another complication is that when long fault zones in normal fault regimes fail, they may break along segments rather than along the entire length. Large (M greater than 7) earthquakes in the western Great Basin tend to be followed by aftershocks lasting about a century and then seismic activity stabilizes at a low level for centuries or thousands of years. Based on this concept, recurrence estimates based on historic or current earthquake distributions may not be directly applicable to the problem of identifying the most likely locations of future large earthquakes (DOE 1986).

From the historical seismicity of the southern Great Basin (two earthquakes of M equals 6) and length of active faults, a maximum magnitude of M equals 7 to 8 is inferred for earthquakes in the Yucca Mountain region. Estimates of recurrence intervals for major earthquakes in the region (M is greater than or equal to 7) are on the order of 25,000 years; for magnitudes of greater than or equal to 6, recurrence intervals are on the order of 2,500 years; and for magnitudes of greater than or equal to 5, recurrence intervals are on the order of 250 years (DOE 1986).

Ground motion acceleration resulting from earthquakes may cause damage to buildings and other structures. Ground motion acceleration is represented by the unit (g), which is the acceleration due to the force of the earth's gravitational field and is approximately equal to 986 centimeters per square second (DOE/NV 1993a). A maximum horizontal ground surface acceleration of 0.34g at the NTS is estimated to result from an earthquake that could occur once every 2,000 years (DOE 1994). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

The Massachusetts Mountain earthquake associated with the Cane Spring Fault (the most probable source for seismic activity in the area of the proposed SNF storage facility) discussed above occurred on August 5, 1971 and produced a peak ground motion acceleration of 0.05 g. The maximum credible earthquake associated with the Cane Spring Fault is expected to produce a peak acceleration of 0.67 g (DOE/NV 1993a).

Volcanic activity in the area is evident in the geologic record by the presence of widespread tuffs and scattered granitic plutons deposited during the Tertiary period and basalts deposited during the late Pliocene and Pleistocene epochs (DOE 1988b).

The potential for renewed silicic volcanism is suggested by the youngest (7- to 8-million year old) major silicic volcanic center in the area, the Black mountain center, located just west of the northwest corner of the NTS. However, the occurrence of silicic volcanism near the NTS during the next 10,000 years is considered unlikely due to: no silicic volcanism in the south-central Great Basin during at least the past 6 million years, the decrease of silicic volcanism throughout the central and southern parts of the Great Basin during the past 10 million years, and the restriction of silicic volcanism to the margins of the Great Basin during the Quaternary (the past 2 million years). If silicic volcanism were to occur, the most likely effect at NTS would be the

deposition of air-fall tuff from eruptions of silicic centers near the western margin of the Great Basin, as happened at least twice during the Pleistocene. Such volcanism could result in the deposition of fine-grained volcanic ash in layers ranging from a few millimeters to tens of centimeters thick (DOE 1988b).

The possibility of future basaltic volcanism near the NTS is suggested by Quaternary basaltic volcanism, notably in the Crater Flat basalt field, just west of the southwest corner of the NTS. However, future basaltic eruptions would likely be small and short-lived judging from the Quaternary record of basaltic volcanism due to: magma volumes for eruptions in the vicinity of the NTS during the past 8 million years being generally less than 1.0×10^8 cubic meters (3.5×10^9 cubic feet), and of short duration; a low rate of magma generation in the south-central Great Basin during the late Cenozoic as reflected by the small-volume, basalt eruptive cycles in the region; and the lack of geologic or geochemical patterns indicating that the rates of volcanism in the southern Great Basin are increasing, that such rates might increase in the future, or that basaltic activity could evolve into more voluminous types of basalt fields. The probability for the penetration of a repository at Yucca Mountain by basaltic volcanism was calculated based upon studies of volcanic deposits in the vicinity. According to these calculations, the annual probability is estimated as 3.3×10^{-10} to 4.7×10^{-8} (DOE 1988b).

4.7 Air Resources

Because the transport of airborne effluents is affected by meteorological conditions, the climatology at the NTS is discussed in this section. A summary of air monitoring networks is then included. Finally, the most recent air quality data available are presented.

4.7.1 Climatology

The climate at the NTS and the surrounding region is characterized by high solar radiation, limited precipitation, low relative humidity, and large diurnal temperature ranges. The lower elevations have a climate typical of the Great Basin.

NTS is situated at the edge of the Mojave Desert, and the arid climate is typical of the Great Basin. The Sierra Nevada Mountains of California and the series of mountains exceeding 1,830 meters (6,000 feet) in height immediately west and north of the NTS have a marked influence on the climate. The prevailing upper level winds are from the west; most of the moisture associated with Pacific Ocean storms falls on the western slopes of the Sierra Nevada. East of the Sierra Nevada, at locations such as the NTS, very little precipitation occurs.

The Weather Services Office at the NTS monitors meteorological data from numerous observation sites within and in the vicinity of the NTS. The nearest National Weather Service full-time meteorological monitoring station is at McCarran International Airport, Las Vegas.

At Area 6 of the NTS, the average daily maximum/minimum temperatures during the month of January are 10.6°C/-6.1°C (51°F/21°F). The average daily maximum/minimum temperatures are 35.6°C/13.9°C (96°F/57°F) in July. At Las Vegas, the coldest temperature on record is -13.3°C (8°F) and the warmest temperature on record is 46.7°C (116°F).

The average annual precipitation at Area 6 is 15 centimeters (6 inches). Precipitation amounts for each month are generally less than 1.3 centimeters (0.5 inch). At Las Vegas, the greatest precipitation recorded in a 24-hour period is 6.6 centimeters (2.59 inches). An average of 14 thunderstorm days occur each year, with maximum occurrence in July and August. Thunderstorms occasionally become severe. Tornadoes are extremely rare in Nevada. The average relative humidity at 4 AM in Las Vegas is 40 percent. The average relative humidity at 4 PM is 20 percent.

Low-level surface winds at the NTS are influenced by the large-scale weather patterns interacting with the mountain ranges, which generally run from north to south. Predominant winds are from the south during the summer and north during the winter. The general downward slope in the terrain from north to south across the NTS results in a diurnal wind reversal from the south during the day to the north during the night. At Area 6, the average annual wind speed is 11 kilometers per hour (7 miles per hour). Occasionally, strong winds associated with storms will exceed 82 kilometers per hour (50 miles per hour). These events are most common in the spring. At Las Vegas, the peak wind gust on record is 145 kilometers per hour (90 miles per hour). Strong winds interacting with dry soil conditions are responsible for occasional duststorms or sandstorms.

Wind direction and speed are major factors in planning and conducting nuclear tests, where atmospheric transport is the primary potential route of contamination to onsite workers and offsite populations. Figure 4.7-1 presents 10-meter (33-feet) wind roses for the NTS in 1990. A wind rose presents the frequency distribution of wind directions at a particular location. The wind roses indicate that there are differences in prevailing wind directions across the NTS. Mountain slopes and valleys are major determinants in these localized variations (DOE/NV 1993c; National Climatic Data Center 1991).

Atmospheric dispersion improves as the wind speed increases, conditions become more unstable, and the depth of the mixing height increases. The transport and dispersion of airborne material are direct functions of air movement. Transport directions and speeds are governed by the general patterns of air flow (and by the nature of the terrain), whereas the diffusion of airborne material is governed by small-scale, random eddying of the atmosphere (i.e., turbulence). Turbulence is indicated by atmospheric stability classification. Data collected at Desert Rock for calendar year 1990 indicated that atmospheric conditions were unstable (i.e., Stability Classes A through C) approximately 25 percent of the time, neutral (Class D) approximately 37 percent of the time, and stable (Classes E through G) approximately 37 percent of the time for that year.

4.7.2 Air Monitoring Networks

4.7.2.1 Radiological Monitoring Network. DOE Order 5400.1, General Environmental Protection Program, established the onsite environmental protection program requirements, authorities, and responsibilities for DOE operations. At the NTS, radiological effluents may originate from tunnels, underground test sites, and facilities where materials are used, processed, stored, or discharged. Airborne radiological effluents at the NTS have the greatest potential for reaching the public. There are two radiological monitoring programs for potential airborne radioactive effluents associated with the NTS, one onsite and the other offsite (DOE/NV 1993c).

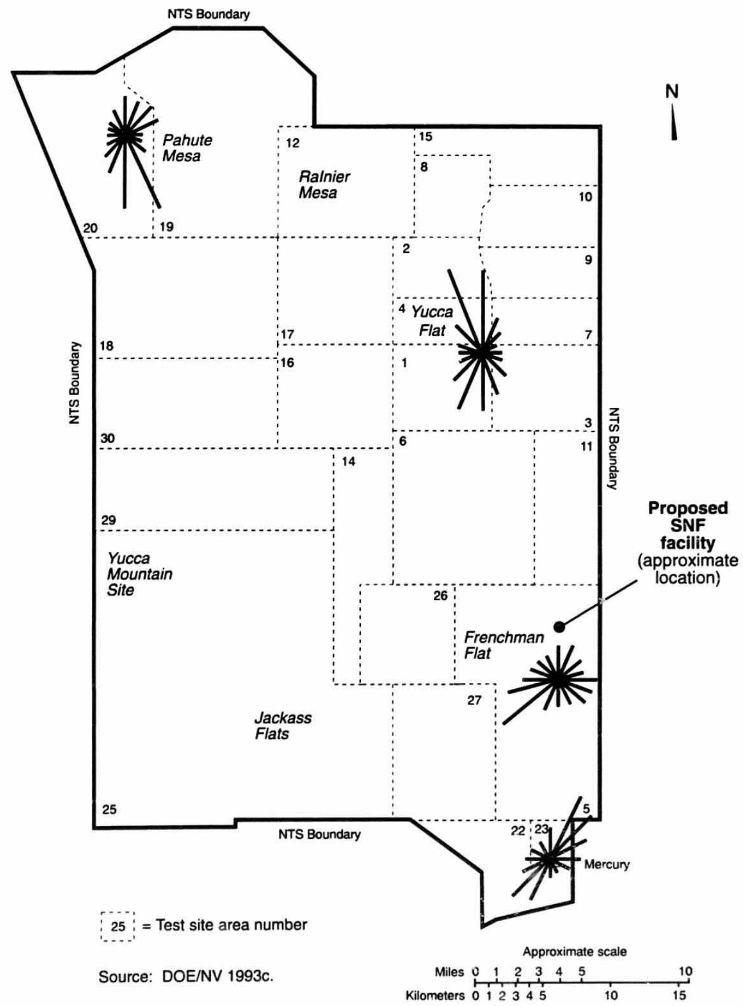


Figure 4.7-1. 1990 10-meter (33-foot) wind rose patterns for the NTS.

The onsite environmental surveillance program consists of 52 air sampling stations collecting particulates and reactive gases; 17 samplers collecting atmospheric moisture for tritium analysis; 10 samplers collecting air samples for noble gas analysis; 63 water sampling locations that include wells, springs, reservoirs, and ponds onsite; and 187 locations where thermoluminescent dosimeters are positioned for measurement of external gamma exposures (DOE/NV 1993c).

The offsite radiological monitoring program is conducted around the NTS by the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring Systems Laboratory, Las Vegas, under an interagency agreement. This program consists of several extensive environmental sampling, radiation detection, and dosimetry networks. In 1992, the Air Surveillance Network was made up of 30 continuously operating sampling locations surrounding the NTS and 77 standby stations (operating one week each quarter) in all states west of the Mississippi River. During 1992, no airborne radioactivity related to current nuclear testing at the NTS was detected on any sample from this network (DOE/NV 1993c).

4.7.2.2 Nonradiological Monitoring Network. Nonradiological environmental monitoring of NTS operations involved only onsite monitoring because there were no nonradiological hazardous material discharges offsite.

4.7.3 Air Releases

4.7.3.1 Radiological. The majority of radioactive effluents at NTS in 1992 originated from underground nuclear tests designed and conducted by two national laboratories and the Defense Nuclear Agency. The Los Alamos National Laboratory of Los Alamos, New Mexico and the Lawrence Livermore National Laboratory of Livermore, California conducted tests in support of DOE nuclear testing program objectives. Sandia National Laboratories of Albuquerque, New Mexico supported tests conducted by the Defense Nuclear Agency, which uses the NTS as a nuclear testing facility under an agreement with DOE (DOE/NV 1993c).

The presence of plutonium as an airborne, radioactive effluent at NTS in 1992 is primarily due to previous atmospheric tests and tests in which nuclear devices were detonated with high explosives (called "safety shots"). These latter tests spread low-fired plutonium in the eastern and

northeastern areas of the NTS. Three decades after the conclusion of the atmospheric test program, higher than normal levels of plutonium in the air are still detected in several areas. Because of operational activities and vehicular traffic in Area 3 some of the plutonium becomes airborne and elevated levels of plutonium have been detected in Area 3 for several years (DOE/NV 1993c).

Six underground nuclear tests were conducted at the NTS during 1992. A list of these tests and a summary of environmental monitoring observations for each of these are provided in Table 4.7-1.

Air emissions from nuclear testing operations consisted primarily of radioactive noble gases and tritium released during posttest drillback, mineback, or sampling operations following each of the 1992 underground nuclear tests. None of the tests resulted in a prompt release or venting (release of radioactive materials within 60 minutes of the nuclear test). Onsite radiological safety support included monitoring emissions during the six nuclear tests. Testing included detecting, recording, evaluating, and reporting radiological conditions prior to, during, and for an extended period after each test with provisions for aerial monitoring teams to detect airborne releases (DOE/NV 1993c).

Following each test, when control of the test area was released by the DOE Controller, survey personnel obtained radiation measurements using portable detection instruments. During the postevent drillback and mining activities, continuous environmental surveillance was maintained in the work area. For containment of radioactive releases to the atmosphere during drillback, systems were employed to trap radioactive particles.

Radioactive waste management sites are located in Areas 3 and 5. These sites serve as DOE defense waste disposal sites (DOE/NV 1993c).

NTS airborne radionuclide emissions for 1992 are presented in Table 4.7-2.

4.7.3.2 Nonradiological. Air emissions from the NTS originate from concrete batch plants, aggregate crushing and processing, surface disturbance, fire training exercises, motor

Table 4.7-1. Nuclear test release summary - 1992 at the NTS Site.[a]

Event name	Test org.	Hole/ area no.	Location	Date/ time of event	Prompt release?	Telemetry measurement: Start	Telemetry measurement: Stop	Initial radiation survey: Began	Initial radiation survey: Ended	Maximum exposure rate	Release information
Junction	LANL	U19bg Area 19	Pahute Mesa	03/26/92 0830 hrs	No	03/26/92 0830 hrs	03/27/92 0830 hrs	03/26/92 1029 hrs	03/26/92 1108 hrs	0.05 mR/h	None detected
Diamond Fortune	DNA	U12p.05 Area 12	Rainier Mesa	04/30/92 0930 hrs	No	04/30/92 0930 hrs	05/11/92 1400 hrs	04/30/92 1109 hrs	04/30/92 1143 hrs	0.05 mR/h	Release included 0.242 Ci Xenon-133 and 6.05μCi Iodine-131 (5/4/92 to 7/2/92) from low level seepage until cavity gases were transferred to Distant Zenith chimney
Victoria	LANL	U3kv Area 3	Yucca Basin	06/19/92 0945 hrs	No	06/19/92 0945 hrs	06/24/92 1500 hrs	06/91/92 1014 hrs	06/19/92 1040 hrs	0.05 mR/h	None detected
Galena	LLNL	U9cv Area 9	Yucca Basin	06/23/92 0800 hrs	No	06/23/92 0800 hrs	06/24/92 2200 hrs	06/23/92 0914 hrs	06/23/92 0923 hrs	0.05 mR/h	None detected
Hunters Trophy	DNA	U12n.24 Area 12	Rainier Mesa	09/18/92 1900 hrs	No	09/18/92 1001 hrs	09/22/92 1300 hrs	09/18/92 1116 hrs	09/18/92 1151 hrs	3.0 mR/h	Release of 0.9 Ci of noble gases and tritium (11/18/92 to 1/5/93) from diagnostic studies
Divider	LANL	U3ml Area 3	Yucca Basin	09/23/92 0804 hrs	No	09/23/92 0804 hrs	09/24/92 0941 hrs	09/23/92 0856 hrs	09/23/92 0915 hrs	0.05 mR/h	Release of 0.11 Ci Xenon-133 on 10/14/92 during post shot operations
Distant Zenith	DNA	U12p.04 Area 12	Rainier Mesa	09/19/91 0930 hrs	No	1992 releases associated with ventilation of LOS pipe and drilling in the Chimney region and included: 1.33 Ci^{85}Kr, 2.07 Ci^{37}Ar, and 0.1 μCi^{39}Ar					

a. Source: DOE/NV 1993c.

Table 4.7-2. Airborne radionuclide emissions for 1992 at the NTS.[a]

Event or facility name (airborne releases)	Curies									
	Tritium[b]	Argon-37[c]	Argon-39	Krypton-85	Xenon-127[d]	Xenon-129m[e]	Xenon-131m	Xenon-133m	Iodine-131	Plutonium-239,240
Area 3, DIVIDER								1.1×10^{-1}		
Area 3[f]										2.5×10^{-3}
Area 5, RWMS[f]	6×10^{-1}									
Area 6[g]									1.3×10^{-5}	
Area 12,										
N Tunnel	4.9×10^{-2}	7.9×10^{-1}	8.1×10^{-5}	1.3×10^{-2}	5.7×10^{-6}	2.4×10^{-5}	1.5×10^{-2}	3.9×10^{-2}		
P Tunnel	3.6×10^{-1}	2.1×10^{0}		1.3×10^{0}				2.4×10^{-1}	6.0×10^{-6}	
Area 19 and 20, Pahute Mesa[d]				$2.8 \times 10^{+2}$						
Total	1.0×10^{0}	2.9×10^{0}	8.1×10^{-5}	$2.8 \times 10^{+2}$	5.7×10^{-6}	2.4×10^{-5}	1.5×10^{-2}	3.9×10^{-1}	1.9×10^{-5}	2.5×10^{-3}

a. Source: DOE/NV 1993c.

b. Total includes 4.9×10^{-2} Ci of molecular HT from Hunter's Trophy. Remainder is in the form of tritiated water vapor, primarily HTO.

c. Ar-37 with 35 day half-life not in GENII. Decays to stable $C\ell$-37.

d. Xe-127 with 36.4 day half-life not in GENII. Decays to stable I-127.

e. Xe-127m with 8 day half-life not in GENII. Decays to stable Xe-129.

f. Calculated from air sampler data.

g. Assumes all radioactivity on Anti-C clothing is I-131 and all becomes airborne during drying.

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vehicle operations, boilers, and fuel storage. The concrete batch plants, aggregate crushing and processing facilities, and surface disturbance activities are sources of particulate matter. These activities are largely intermittent and occur in support of specific testing programs on the NTS. Fire training exercises consist of periodic open burning in designated areas with approved fuel materials conducted by fire and emergency personnel several times per year. Motor vehicle operations and boilers are the largest sources of air pollutants at the NTS; motor vehicles consume gasoline, while boilers, construction equipment, and other diesel engines consume diesel fuel. A continuous, nonradiological air monitoring network is not in place at the NTS (USAF et al. 1991). Table 4.7-3 presents the maximum allowable nonradiological emission rates for those NTS sources which require permits.

4.7.4 Air Quality

4.7.4.1 Radiological. Onsite surveillance of airborne particulates, noble gases, and tritiated water vapor indicated onsite concentrations that were generally not statistically different from background concentrations. External gamma exposure monitoring in 1992 indicated that the gamma environment within the NTS remained consistent with that of previous years. All gamma monitoring stations displayed expected results, ranging from the background levels predominant throughout the NTS to the types of exposure rates associated with known contaminated zones and radiological material storage facilities. Results of 1992 offsite environmental surveillance indicated no NTS-related radioactivity was detected at any air sampling station, and there were no apparent net exposures detectable by the offsite dosimetry network (DOE/NV 1993c).

The GENII environmental transport and dose assessment model (PNL 1988) was used to calculate the effective dose equivalents (EDE) resulting from the airborne radionuclide emissions presented in Table 4.7-2. These results are summarized in Table 4.7-4. The maximum EDE at the NTS boundary is 1.1×10^{-2} millirem. This is 1.1×10^{-1} percent of the corresponding National Emissions Standard for Hazardous Air Pollutants. The collective EDEs to the estimated population of 15,100 persons within 80 kilometers (50 miles) of the proposed SNF facility is 5.2×10^{-3} person-rem, which is 1.2×10^{-4} percent of the natural background radiation dose affecting this population. Background radiation doses are presented in Figure 4.7-2.

Table 4.7-3. Total nonradiological emission rates at NTS for permitted sources.[a]

Pollutant	Emission rate (g/s)
Carbon monoxide	b
Nitrogen dioxide	b
Particulate matter (PM_{10})	2.8
Sulfur dioxide	4.5
Lead	b

a. Source: Engineering Science, Inc. (1990).

b. No pollutant sources indicated.

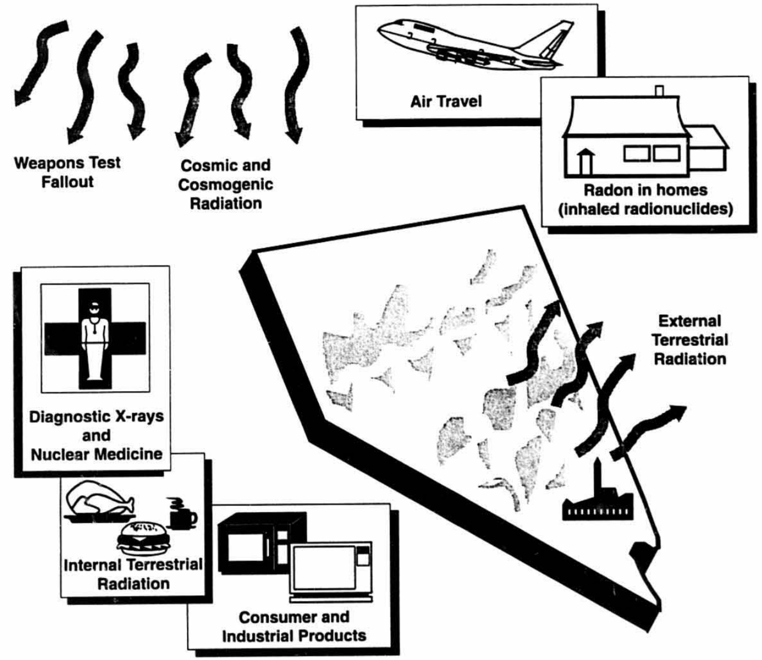
Table 4.7-4. Summary of effective dose equivalents to the public from NTS operations during 1992.[a]

	Maximally exposed individual dose[b]	Collective dose to the population within 80 km of NTS sources[c]
Dose	1.1×10^{-2} mrem	5.2×10^{-3} person-rem
NESHAP standard	10 mrem per year	--
Percentage of NESHAP	1.1×10^{-1}	--
Natural background dose	278 mrem per year	4190 person-rem per year
Percentage of natural background dose	4.0×10^{-3}	1.2×10^{-4}

a. Sources: 1992 Radionuclide emissions from DOE/NV 1993c GENII Model (PNL 1988) used to predict EDE. Natural background dose from DOE/NV 1993c.

b. The maximum boundary dose is to the hypothetical individual who remains in the open continuously during the year at the NTS boundary.

c. Based on an estimated population of 15,100 persons within 80 km of the proposed SNF facility in 1995.



	millirem per years[a]
Natural Background Radiation	
External penetrating radiation and Internal terrestrial radiation	78
Radon in homes (inhaled)	200
Other Background Radiation	
Diagnostic X-rays and nuclear medicine	53
Weapons test fallout	<1
Air travel	1
Consumer and industrial products	10
Total	343

[a]Committed effective dose equivalent to a hypothetical resident of Indian Springs, NV.

Sources: DOE/NV 1993c; NCRP 1987; Value for radon is an average for the United States.

Figure 4.7-2. Sources of radiation exposure, unrelated to NTS operations, to individuals in the vicinity of NTS.

4.7.4.2 Nonradiological. Air quality rules and regulations applicable to the NTS are governed by the Clean Air Act, the Nevada Revised Statutes, and the Nevada Administrative Code. The EPA administers the Federal regulations developed to implement the Clean Air Act, and the Nevada Department of Conservation and Natural Resources is responsible for enforcing the Federal and state regulations. Air quality in a given location is described as the concentration of various pollutants in the atmosphere, generally expressed in units of micrograms per cubic meter ($\mu g/m^3$).

The Clean Air Act directed the EPA to set National Ambient Air Quality Standards (NAAQS) for those pollutants, termed criteria pollutants, that pose the greatest threat to air quality in the United States. The six criteria pollutants are ozone, carbon monoxide, sulfur dioxide, lead, nitrogen dioxide, and particulate matter with an aerodynamic particle diameter less than or equal to 10 microns, referred to as PM_{10}. The Clean Air Act Amendments authorized the EPA to designate geographic regions not in compliance with NAAQS as nonattainment areas. The NTS is located within the Nevada Air Quality Control Region 147, which is in attainment with respect to the NAAQS for the criteria pollutants (CFR 1993b; Engineering Science, Inc. 1990). The nearest nonattainment areas to the Nevada Test Site Spent Nuclear Fuel site are in Clark County, which includes an area in the Las Vegas planning area that is designated serious for PM_{10} and an area in Las Vegas that is designated moderate for carbon monoxide (CFR 1993b).

Under the Clean Air Act, clean air areas are divided into classes. National parks and wilderness areas receive mandatory Class I protection. Very little pollution increase is allowed in Class I areas. The only Class I area in Nevada, the Jarbridge Wilderness Area, is located approximately 480 kilometers (300 miles) from the NTS, in the northwest corner of Nevada. The nearest Class I areas to the NTS are the Grand Canyon National Park, approximately 275 kilometers (171 miles) to the southeast, and Sequoia National Park approximately 175 kilometers (109 miles) to the west-southwest. The NTS is located in a Class II area, as are most areas across the country.

In addition to the criteria pollutants which are regulated under the National Ambient Air Quality Standards and under various emission standards, hazardous air pollutants are regulated.

Title III of the Clean Air Act Amendments of 1990 directed the EPA to determine maximum available control technologies which would be used as the basis for emission limits for the hazardous air pollutants.

Engineering Science, Inc. of Pasadena, California conducted an air quality study at the NTS in 1990. The study examined air quality compliance of the NTS with applicable Federal and state air quality standards. The study encompassed an air emissions inventory, ambient air monitoring, and air pollution source testing at various sources. Based on the data collected at the ambient air monitoring stations established for the study, air quality at the NTS is within applicable Federal and state standards. The results of background monitoring performed by Engineering Science, Inc. are summarized in Table 4.7-5. This is the most recent comprehensive analysis of NTS ambient air quality.

Air dispersion modeling was performed to determine the maximum concentrations of the criteria pollutants. These results are also summarized in Table 4.7-5. The "total existing maximum concentrations" in Table 4.7-5 would result if all permitted sources at the NTS operated at the maximum allowable capacity. All pollutant concentrations from this worst-case scenario of existing emissions at the NTS are below applicable regulations.

4.8 Water Resources

This section provides a description of the surface water and groundwater at the NTS and surrounding area. The section also describes the existing impacts to surface water and groundwater that have resulted from past and present operations at the NTS.

4.8.1 Surface Water

The drainage basins and the generalized directions of surface water flow near the NTS are shown in Figure 4.8-1 (USAF et al. 1991). The boundary lines of the drainage basins occur principally along topographic divides (DOE 1988b). Figure 4.8-1 also shows other surface water features.

Table 4.7-5. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at the NTS.[a]

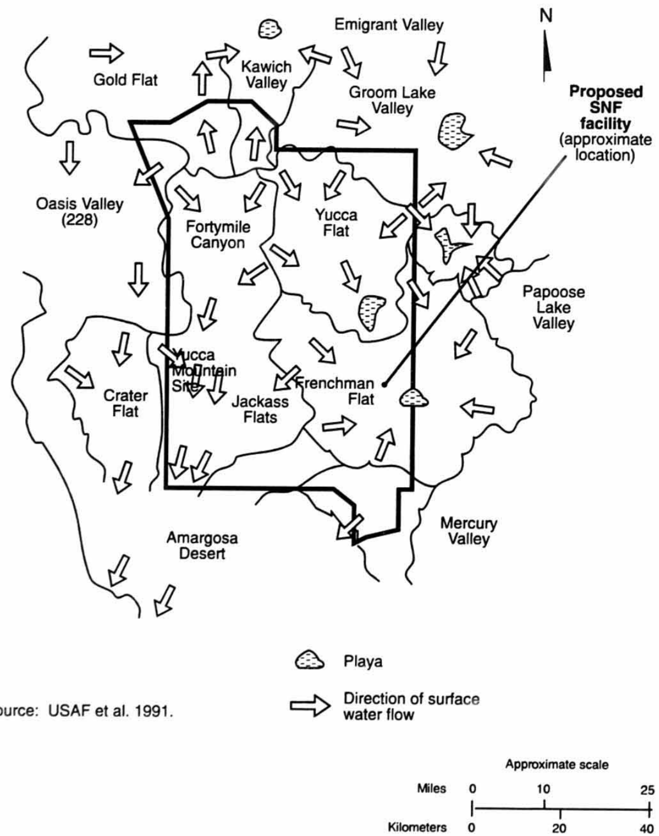
Criteria pollutant	Averaging time	Most stringent regulation or guideline ($\mu g/m^3$)	Maximum background concentration ($\mu g/m^3$)	Maximum existing DOE site contribution ($\mu g/m^3$)	Total existing maximum concentration ($\mu g/m^3$)
Carbon monoxide	8-hour	10,000	2,290	b	2,290
	1-hour	40,000	2,748	b	2,748
Nitrogen dioxide	Annual	100	c	b	b
Lead	Calendar quarter	1.5	c	b	b
Particulate matter (PM_{10})[d]	Annual	50	c	0.43	0.43
	24-hour	150	78.3	6.6	84.9
Sulfur dioxide	Annual	80	c	1.07	1.07
	24-hour	365	39.3	15.9	55.2
	3-hour	1,300	65.4	104.9	170.3
Hazardous air pollutants					
b	b	b	b		

a. Sources: Maximum background concentration provided by Engineering Science, Inc. (1990). Maximum existing DOE site contribution computed by Halliburton NUS.

b. No sources indicated.

c. Not measured.

d. All suspended particulate matter is assumed to be PM^{10}.



Source: USAF et al. 1991.

Figure 4.8-1. NTS hydrologic basins and surface drainage direction.

Almost all stream flow in the NTS area is ephemeral, and therefore almost no streamflow data have been collected. The average annual runoff within the hydrographic areas in the Death Valley Basin in Nye County was estimated at less than 164 million gallons (620,000 cubic meters) per area (DOE 1988b).

The ephemeral character of streamflow has also limited the onsite monitoring of surface water quality. Water samples were, however, collected from the main channel of Fortymile Wash and two of its principal tributaries (Drill Hole Wash and Busted Butte Wash) during periods of runoff and flooding in 1984. Due to unknown factors such as compositional variability of storms, any quantitative interpretation is unwarranted (DOE 1988b).

Throughout the NTS, perennial surface water originates solely from springs, and it is restricted to source pools at some large springs. Because of the extreme aridity of this region, most of the spring discharge travels a short distance before evaporating or infiltrating back into the ground (DOE 1986). Thus, dry washes may be the principal sources of potential groundwater recharge inputs in the area (DOE 1988b). In addition, playas on NTS, including Frenchman Lake located in Area 5 and Yucca Lake to the northwest of Area 5, may retain standing water for hours to weeks following intense precipitation events. These playas represent the only natural surface water features in the vicinity of Frenchman and Yucca Flats. The direction of movement of water accumulated in playas is generally upward due to high evapotranspiration (DOE/OFE 1994). However, accumulated runoff in Frenchman Lake and Yucca Lake reportedly serves to recharge the valley fill aquifer (DOE 1988b).

Despite the arid climate, which includes high annual average potential evaporation, low average annual precipitation, and infrequent storms, surface runoff does occur. Runoff results from storms that occur most commonly in winter and occasionally in autumn and spring, and from localized thunderstorms that occur mostly during the summer (DOE 1988b). The ephemeral streams resulting from heavy precipitation fill the normally dry washes. Local flooding may occur where the water exceeds the capacity of the channels. In contrast to the washes, the terminal playas may retain standing water for days or weeks after severe storms (DOE 1986). Playas in Kawich Valley and Gold Flat collect and dissipate the runoff from the northern part of Pahute Mesa (ERDA 1977). Summer floods usually do not accumulate to cause regional floods, but their intensive character renders them potentially destructive over limited areas (DOE 1988b).

The western half and southernmost part of the NTS have channel systems which carry runoff beyond NTS boundaries during infrequent, very intense storms. Fortymile Canyon is the largest of these systems, originating on Pahute Mesa in the northwestern part of the NTS and draining into the normally dry Amargosa River channel about 20 miles (32 kilometers) southwest of the NTS. Within the NTS, Fortymile Canyon and its tributaries are restricted to well-incised canyons. Flood-prone areas surround Fortymile Wash, a major tributary within Fortymile Canyon. The other major NTS tributaries to the Amargosa River are Tonopah Wash, which runs southwesterly from Jackass Divide in the south-central part of the NTS into the Amargosa Desert near Amargosa Valley, and Rock Valley, which drains from the southernmost part of the NTS westward and then southward to Ash Meadows in the east-central portion of the Amargosa Desert (ERDA 1977).

The Amargosa River originates in Oasis Valley and continues southeastward through the Amargosa Desert past Death Valley Junction, then southward another 45 miles (82 kilometers), where it turns northwestward and terminates in Death Valley. The river carries floodwaters following cloudbursts or intense storms but is normally dry, except for a few short reaches that contain water from springs (DOE 1988b).

Two watersheds, Fortymile Canyon and Jackass Flats, have the potential of endangering offsite public health and safety due to flooding. Regional peak-flood flow equations for the southern Nevada area indicate that the 100-year peak flow from the Fortymile Canyon drainage is approximately 13,000 cubic feet (370 cubic meters) per second and 8,200 cubic feet (230 cubic meters) per second from the Jackass Flats drainage (USAF et al. 1991).

In summary, the potential exists for sheet flow and channelized flow through ephemeral washes from intense precipitation events to cause localized flooding throughout the NTS; however, no comprehensive floodplain analysis has been conducted on the NTS to delineate the 100- and 500-year floodplains associated with NTS drainages. No flood studies are known to have been conducted for the proposed SNF facility in Area 5; a flood assessment was conducted

for the Radioactive Waste Management Site in NTS Area 5 on Frenchman Flat, located southwest of the proposed SNF Site. This study determined that the southwest corner of the Radioactive Waste Management Site is located in Federal Emergency Management Agency Zone AO (100-year flood zone with depths between 1 and 3 feet [0.3 and 0.9 meter]) of the Barren Wash Alluvial Fan. The remainder of the Radioactive Waste Management Site is located in Zone X of the Halfpint Alluvial Fan (100-year flood zone with depths less than 1 foot [0.3 meter]). Areas to the north, south, and east of the Radioactive Waste Management Site are in Zone X or Zone AO (DOE/NV 1993d). These suggest that the proposed SNF facility area may encompass areas in Zone X and/or areas in Zone AO associated with the Halfpint Alluvial Fan. Probable maximum flood analyses are known to have been performed only for areas in the vicinity of Yucca Mountain to aid in flood protection design for Yucca Mountain facilities (DOE 1988b).

Underground nuclear testing has resulted in the release of radioactive materials at the land surface. There is the potential for 100-year floods to transport these contaminants beyond the boundaries of the NTS. Quantitative estimates of this potential cannot be determined without additional studies (USAF et al. 1991).

There are no National Pollutant Discharge Elimination System (NPDES) permits for the NTS, as there are no wastewater discharges to onsite or offsite surface water. NTS sanitary wastewaters are discharged to sewage lagoons or to septic tank/leach field systems. All wastewater discharges at NTS are conducted in accordance with permits issued by the State of Nevada (DOE/NV 1993c).

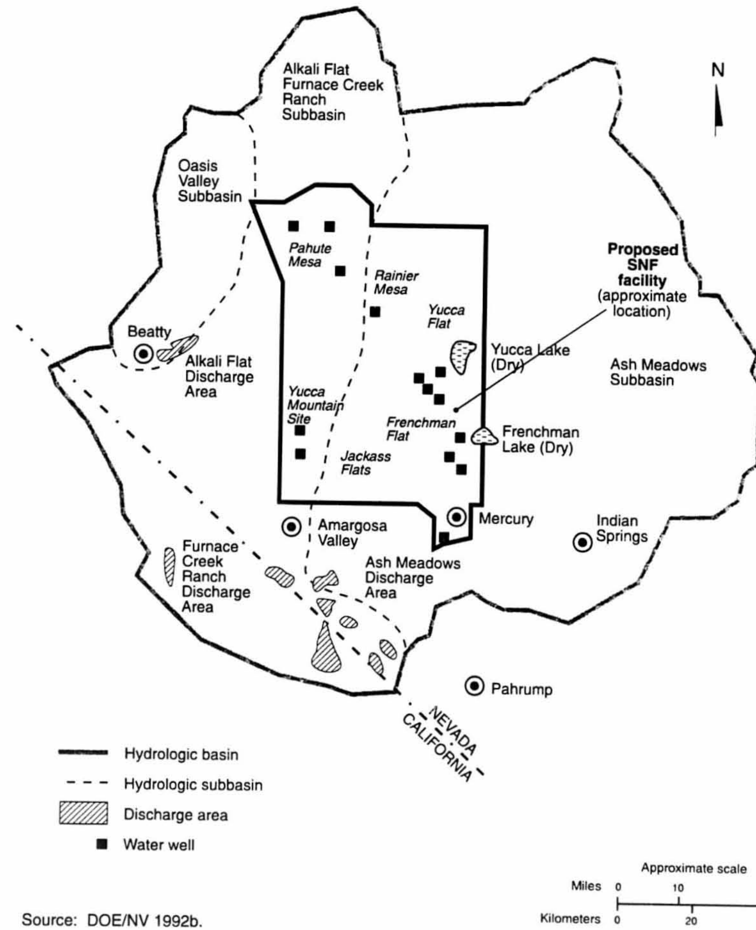
4.8.2 Groundwater

Generally, the hydrogeology at the NTS is characterized by great depths to the groundwater table and slow velocity of movement of water in the saturated and unsaturated zones (DOE/NV 1992c). Depth to groundwater varies from about 660 feet (200 meters) beneath valleys in the southern part of the NTS to more than 1,640 feet (500 meters) beneath Pahute Mesa. The depth of the water table below Area 5 is approximately 800 feet (244 meters) below land surface (DOE/NV 1993c). Locally, there are perched water tables at shallow depths (USAF et al. 1991).

Perched aquifers have been reported at depths of 70 feet (21 meters) in the southwestern part of Frenchman Flat (RSN 1993). In the eastern portions of the NTS, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer (DOE/NV 1993c).

The NTS lies within the Death Valley Groundwater System, which is a large and diverse area encompassing southern Nevada and adjacent parts of California composed of many mountain ranges and topographic basins that are hydraulically connected at depth. In general, groundwater within the system travels toward Death Valley, although much of it discharges before reaching it. Groundwater in the Death Valley system does not enter neighboring groundwater systems (DOE 1986). The Death Valley Groundwater System is divided into several groundwater subbasins. The boundaries of these subbasins have been estimated from potentiometric levels, geologic controls of subsurface flow, discharge areas, and inferred flow paths (DOE 1988b). As shown in Figure 4.8-2, the three groundwater subbasins of the system beneath the NTS are Ash Meadows, Alkali Flat Furnace Creek Ranch, and Oasis Valley. Groundwater beneath the eastern part of the NTS is in the Ash Meadows Subbasin. Most of the western NTS is in the Alkali Flat Furnace Creek Ranch Subbasin. Groundwater beneath the far northwestern corner of the NTS occurs in the Oasis Valley Subbasin (DOE/NV 1993c, 1992b).

Six major aquifers occur in the area. In decreasing order of age of the geologic units in which they are found, they are: Cambrian through Devonian lower carbonate aquifer, Pennsylvanian and Permian upper carbonate aquifer, Tertiary bedded tuff aquifer, Tertiary welded tuff aquifer, Tertiary lava flow aquifer, and Tertiary and Quaternary valley fill aquifer (Eckel 1968) (see Figure 4.6-2). The hydrologic and geologic properties of these aquifers vary (see the Yucca Mountain Site Characterization Plan [DOE 1988b] for a thorough description of the hydraulic properties of the major hydrostratigraphic units based on studies at Yucca Mountain). For example, the carbonate aquifers and the welded tuff aquifer store and transmit water chiefly along fractures. In contrast, the valley fill aquifer stores and transmits water chiefly through interstitial openings. Additionally, in places in the lower carbonate aquifer, groundwater flow is diverted laterally and vertically because of fault displacements that have juxtaposed the lower carbonate aquifer against less permeable rocks. Where the flow is blocked, intersection of the water table with the land surface causes springs (DOE 1986).



Source: DOE/NV 1992b.

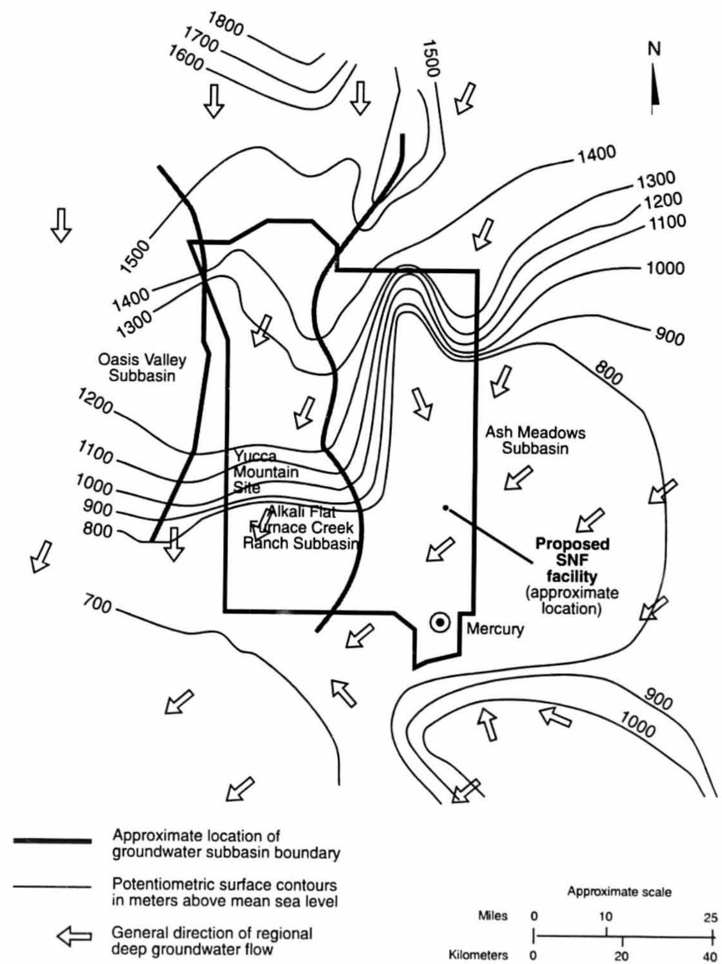
Figure 4.8-2. Groundwater hydrologic units, hydrographic areas, and well locations of the Nevada Test Site.

The lower carbonate and valley fill (alluvial) aquifers are the main sources of groundwater in the eastern part of the NTS (DOE 1986). Groundwater withdrawals in the area of the proposed SNF management facilities are principally from the valley fill aquifer of the Frenchman Flat hydrographic area (DOE 1988b). The other four units in the area have relatively low permeabilities that tend to retard the flow of groundwater. These units are called aquitards (DOE 1986). In decreasing order of age of the geologic units that form them, these aquitards are: Precambrian through lower Cambrian lower clastic aquitard, Devonian through Mississippian upper clastic aquitard, Tertiary tuff aquitard, and Tertiary lava flow aquitard (Eckel 1968) (see Figure 4.6-2).

Figure 4.8-3 is a regional groundwater potentiometric surface map of the NTS (DOE/NV 1993d). The map does not show perched groundwater. However, perched groundwater does occur at NTS, principally associated with the aquitards underlying the ridges (Eckel 1968).

In general, regional groundwater flow is from the north and northeast toward the regional discharge area near Ash Meadows in the Amargosa Desert (see Figure 4.8-2 and 4.8-3). In the western portions of the area, the regional flow is from the northwest to the south and southwest (DRI 1986b). Deep regional movement of groundwater south of the NTS occurs chiefly through the lower carbonate aquifer. Because of geologic structure, flow paths in the lower carbonate aquifer are complex and poorly defined. Groundwater from the Ash Meadow Subbasin supplies the water entering Devil's Hole, which supports the only known population of the Devil's Hole pupfish, a federally listed endangered species. The decline of the species has been attributed to low water levels caused by decreasing groundwater levels (ERDA 1977).

Groundwater recharge to the Ash Meadows Subbasin occurs primarily from precipitation over the mountainous areas in the northern, eastern, and southern portions of the basin (DOE 1988b). As mentioned above, this recharge generally travels vertically through the vadose zone (unsaturated zone) and the overlying aquifers to the underlying carbonate aquifers. Specifically, in the eastern half of the NTS, groundwater flows toward the major valleys before deflecting downward to join the regional flow in the carbonate aquifers. Beneath Yucca and Frenchman flats, vertical flow through the underlying volcanic rocks is impeded by bedded and



Source: DOE/NV 1993d.

Figure 4.8-3. NTS regional potentiometric surface map.

zeolitized tuffs, resulting in a downward flow rate of less than 0.2 foot (0.06 meter) per year. Vertical flow in the uppermost portions of the vadose zone in the area of Frenchman Flat is generally upward toward the surface, due to an evapotranspiration rate which is 15 times higher than precipitation (DOE/OFE 1994). Site characterization data for Area 5 indicate that the vertical flow direction in the vadose zone is upward from 0 to 250 feet (0 to 75 meters) below land surface. In the next interval (250 to 600 feet [75 to 180 meters]), a downward flow rate of 10 feet/1,000 years (3 meters/1,000 years) has been calculated. At a depth of 600 to 800 feet (180 to 250 meters), a zone of equilibrium (a zone of no vertical movement) is present above the water table (Johnejack et al. 1994).

Analyses have also been conducted in order to determine the travel time of water from the vicinity of Area 5 and Frenchman Flat to the regional water table. Modeling studies for the Radioactive Waste Management Site at Area 5 indicate that the travel time from the surface to the water table is on the order of thousands of years (DOE/NV 1993c). Specifically, the travel time from Area 5 to the regional water table is estimated to range from 19,000 to more than 113,000 years (USAF et al. 1991). The Yucca Mountain Site Characterization Plan (DOE 1988b) describes in detail the hydraulic properties of the various units comprising the unsaturated zone, based on studies at Yucca Mountain.

Three types of groundwater chemistry exist at the NTS and in its vicinity: (1) sodium and potassium bicarbonate, which generally occurs in the tuff and valley fill aquifers composed chiefly of tuff detritus; (2) calcium and magnesium bicarbonate, which generally occurs in the carbonate and the valley fill aquifers composed chiefly of carbonate detritus; and (3) mixed, which is defined as having the chemical characteristics of both type 1 and type 2 (DOE 1986).

The hydrogeologic units which supply potable water to the NTS have been classified as Class IIA (currently a source of drinking water) and IIB (potentially a source of drinking water) in accordance with the EPA's guidelines for groundwater classification (DOE/NV 1993d). No aquifers at the NTS have been designated as sole source aquifers.

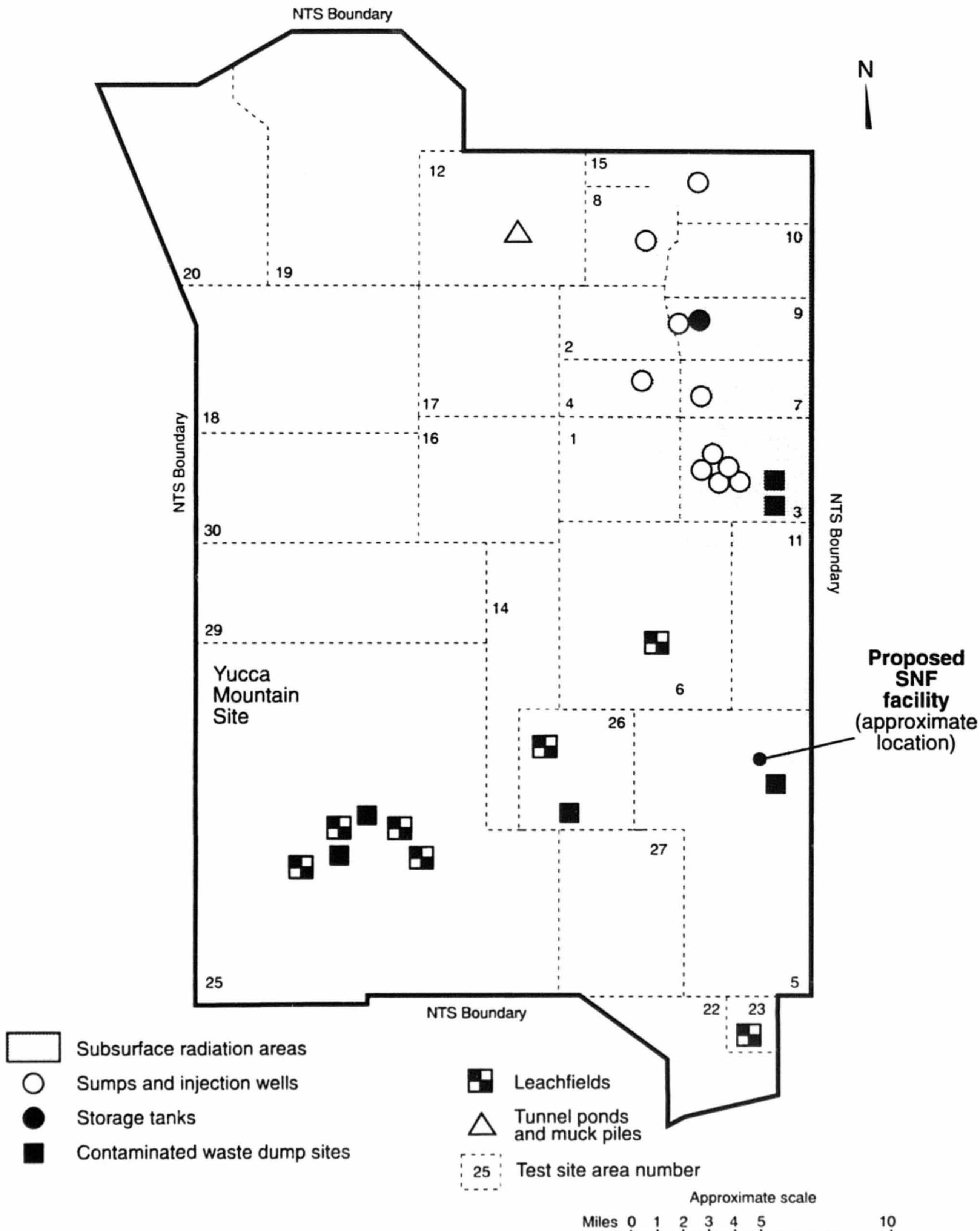
In general, the quality of NTS groundwater is suitable for most purposes and generally meets EPA secondary standards for major cations and anions and the primary standards for

deleterious constituents. Specifically, groundwater in the Ash Meadows Subbasin has a total dissolved solids concentration ranging between 275 and 450 milligrams per liter (mg/L) (DOE/NV 1993a). Summary groundwater quality data for the period 1957 to 1990 for Well 5b, 5c, Well UE5c, and Army Well 1 which serve Area 5 reveal a pH range of 7.6 to 8.7; calcium (2.4 to 44.0 mg/L); sodium (38.1 to 129.0 mg/L); chloride (9.1 to 23.2 mg/L); sulfate (26 to 58 mg/L); and silica (0 to 55.1 mg/L) (DRI 1993).

Contamination by radionuclides occurs below the water table as well as in the unsaturated zone above it. This contamination is a result of underground nuclear testing. A preliminary environmental survey of the NTS also identified a number of potential sources of groundwater contamination. These included wastewater discharges, hazardous- or mixed-waste discharges, solid waste landfills and trenches receiving potentially hazardous waste, and over 50 inactive waste spill or release sites (USAF et al. 1991).

Underground nuclear testing has primarily occurred in the areas of Yucca Flat, Frenchman Flat, Pahute Mesa, Rainier Mesa, and Shoshone Mountain. Nuclear detonations at or near the water table have resulted in groundwater contamination. The principal confirmed or suspected contaminants from these tests include various radionuclides (primarily tritium) and heavy metals. A number of NTS waste disposal and testing facilities, including injection wells, leach fields, and various waste storage facilities or disposal sites, have caused contamination of the vadose zone. Contaminants of concern include radionuclides, organic compounds, heavy metals (primarily lead), and hydrocarbons as well as various residues from plastics, drilling muds, and epoxy (DOE/NV 1993e). Figure 4.8-4 depicts the areas with known or suspected groundwater and/or vadose zone contamination. Groundwater contamination characterization activities are in progress at NTS; at present, no contaminant plume maps are available, and available groundwater quality data are not useful for the purposes of site-wide characterization or for comparison with established criteria.

Groundwater contamination could be transported toward the NTS boundary by one of the regional groundwater flow systems. Groundwater flow velocities in these systems range between 6 and 600 feet (1.8 and 183 meters) per year. Because of sorption, however, most nuclides (other than tritium) would move at a much slower rate. The groundwater travel time from the



Source: DOE/NV 1993b, c.

Figure 4.8-4. Areas of potential groundwater contamination at the NTS.

NTS to the Ash Meadows Discharge Area of the Ash Meadows Subbasin Flow System is approximately 300 years. Radioactive decay during this time, coupled with dilution and sorption, should reduce radioactivity concentrations to well below regulatory limits (USAF et al. 1991). Thus, there are no effects on public health and safety, nor are any expected in the foreseeable future.

The NTS derives its complete water supply from the groundwater aquifers underlying the site. Water supply has been developed and is managed on the basis of five service areas that support the different NTS operating areas. Given the wastewater disposal practices on the NTS and the depth to the groundwater system, it is reasonable to assume that all of the water pumped on the NTS is consumed (USAF et al. 1991). Recent annual water use at the NTS has declined substantially from the 1980's. In 1989, NTS annual water withdrawal was 1.117 billion gallons (4.22 million cubic meters) (Leppert 1993). In 1992, NTS annual water withdrawal was 0.595 billion gallons (2.25 million cubic meters) (Leppert 1993).

In 1993, 14 wells were utilized for the NTS water supply (DOE/NV 1994c). A small portion of the NTS receives its water from 5 onsite wells drilled in the Alkali Flat-Furnace Creek Ranch Subbasin (DOE 1988b). Most of the NTS receives its water from 9 onsite wells drilled in the Ash Meadows Subbasin, which encompasses Area 5 (DOE/NV 1994c). These 9 wells have a combined production capacity of 1.813 billion gallons per year (6.86 million cubic meters per year) (DOE/NV 1993a).

Area 5, which encompasses the proposed SNF facility site, is located within NTS water service area C. Wells 5b, 5c, and UE5c serve the fire protection, construction, and potable water needs of Area 5 facilities (DOE/NV 1993b). Wells 5b and 5c are completed in alluvial materials (valley fill aquifer) with total completion depths of 900 and 1,200 feet (274 and 366 meters) below land surface, respectively. Well UE5c is completed in volcanic rock (exact aquifer unknown) with a total depth of 2,682 feet (817 meters) below land surface (DOE 1988b; DOE/NV 1993b; DRI 1993).

Groundwater for construction and operation of the SNF management facilities would likely be drawn from the Frenchman Flat hydrographic area of the Ash Meadows Subbasin. Much of

the land within the Ash Meadows Subbasin is under Federal jurisdiction and has been withdrawn from the public domain (DOE 1988b). Little of the total groundwater of the subbasin is privately appropriated or used.

The perennial yield of the Ash Meadows Subbasin greatly exceeds water withdrawals by DOE and all other users. For more than thirty years water withdrawals from the Frenchman Flat hydrographic area had exceeded the estimated precipitation recharge for that area (DOE 1988b). This study also indicates that withdrawals have caused no decline in the static water level (DOE 1988b). However, it should be noted that numerous conditions on the NTS preclude the accurate measurement of static water levels (Winograd 1970). Because of hydrogeologic complexities, regional groundwater flow at the NTS is not constrained by the hydrographic basins which are defined by local topography (USAF et al. 1991). Therefore any potential groundwater overdrafts in the Frenchman Flat basin indicated by previous yield estimates are likely made up by untapped groundwater from neighboring hydrographic basins.

Water in southern Nevada (excluding the Las Vegas area) is used chiefly for irrigation and to a lesser extent for livestock, municipal needs, and domestic supplies. Almost all the required water is pumped from the ground, although some springs supply water to establishments in Death Valley and other areas south of the NTS. Springs in Oasis Valley near Beatty, Nevada are a significant source of water for public and domestic needs and for irrigation (DOE 1986). The City of Las Vegas obtains approximately 80 percent of its water from the Colorado River; the remaining 20 percent is withdrawn from groundwater sources. There are no plans to change the water supply sources in the near future. (Las Vegas Valley Water District 1994).

The principal water users in the area closest to the NTS are in the Amargosa Desert in and around the Town of Amargosa Valley and in the Pahrump Valley. Aquifers in the Pahrump Valley could support up to about 16,900 residents with no decline in usable storage, although local effects, such as land subsidence and well interference, could result from sustained development. The mining industry in southern Nevada also uses a small amount of water for processing. Water for this purpose is supplied from nearby shallow wells or trucked in from nearby towns. Many of the mines currently recycle process water, which reduces their water demand (DOE 1986).

The volume of groundwater underlying the NTS (as well as the estimated volume of contaminated groundwater) that has been removed from direct access to the general public is rather large. The impaired groundwater will likely remain unusable for an extended period. The significance of the loss of access to the NTS groundwater is diminished by the fact that even if access were provided, the water underlying portions of the NTS might not be usable for domestic purposes (USAF et al. 1991).

4.9 Ecological Resources

NTS lies within the transition area between the Mojave Desert and the Great Basin. As a result, flora and fauna characteristics of both occur on the NTS. The NTS covers about 3,500 square kilometers (1,350 square miles) of which only 0.55 percent is developed (DOE/NV 1988).

NTS has completed numerous studies on the effects of nuclear testing on the ecology of the area, and an extensive bibliography of these studies has been prepared (ERDA 1976). In summary, studies (including ongoing surveys) have shown that there may be a correlation between radioactive testing and the decline of vegetation present in an area. As a result, animals may not have the necessary vegetation for food and cover, thus changing the fauna diversity in those areas (USAF et al. 1991).

The following section describes the ecological resources at the NTS, including terrestrial resources, wetlands, aquatic ecology, and threatened and endangered species. Information is also presented on special status species other than threatened and endangered species such as Federal Candidate and state-listed species.

4.9.1 Terrestrial Resources

Plant communities on the NTS have been classified according to the dominant shrub. Approximately 700 taxa, representing about 70 families, have been identified on the NTS (ERDA 1976; DOE/NV 1993b, 1991b). Figure 4.9-1 presents the general plant communities identified there.

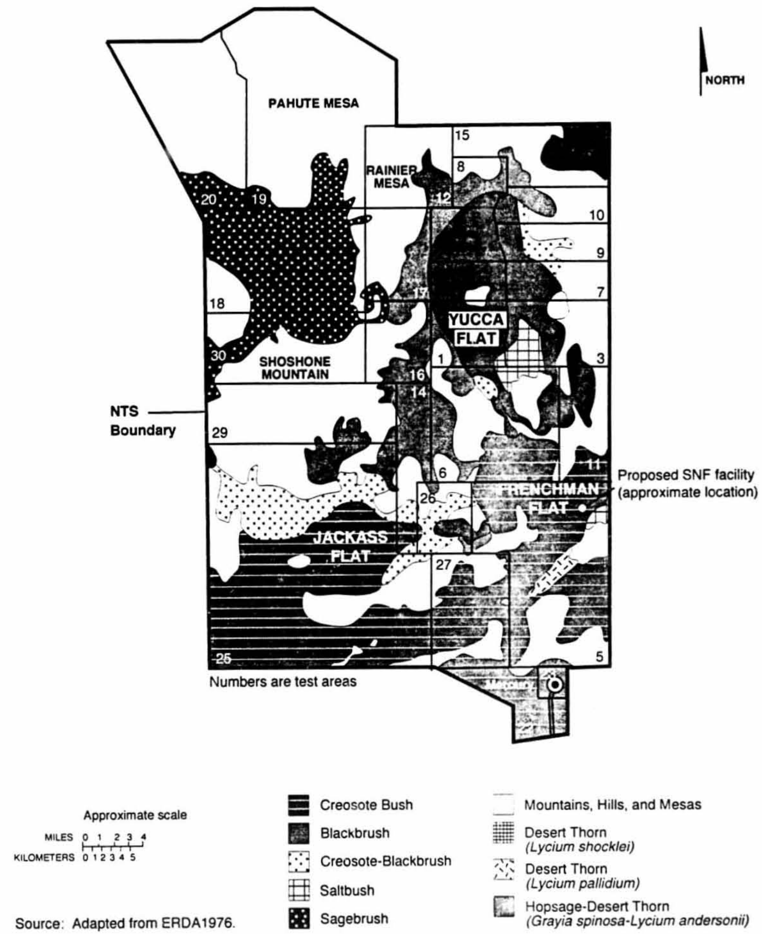


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Figure 4.9-1. Plant communities on Nevada Test Site.

The Mojave Desert is located at elevations ranging up to 1,219 and 1,524 meters (4,000 and 5,000 feet). The dominant plant community is creosote bush (*Larrea tridentata*). Areas in which this community occurs are located within much of the southern portion of the NTS, including Jackass Flats and Frenchman Flat (DOE/NV 1991b, 1986b; ERDA 1976; FWS 1992).

The transitional zone between the Mojave Desert and the Great Basin occurs at elevations between 1,219 and 1,524 meters (4,000 and 5,000 feet). The dominant plant communities associated with the transition zone are: blackbrush (*Coleogyne ramosissma*), desert thorn (*Lycium pallidum*), and hopsage (*Grayia spinosa*). In general, these communities are found in upper bajadas and in closed basins within Jackass Flats and Yucca Flat (DOE/NV 1991b, 1986b; ERDA 1976).

The Great Basin is located within the northern two-thirds of NTS at elevations above 1,524 meters (5,000 feet). The dominant plant communities are big sagebrush (*Artemisia tridentata*) and black sagebrush (*Artemisia nova*), saltbush (*Atriplex canescens*), and desert thorn (*Lycium shockleyi*). In areas with elevations above 1,830 meters (6,000 feet), collectively labeled as mountains, hills, and mesas, the dominant plant communities are singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*). In general, these communities are found at Thirsty Canyon, Yucca Playa, Rainier Mesa, and Yucca Mountain (DOE/NV 1991b, 1986b; ERDA 1976).

There is a recent trend of nonnative plant species establishing themselves in areas of disturbance at the NTS. Cheatgrass (*Bromus tectorum*), an annual grass, occurs at elevations above 1,524 meters (5,000 feet). Downey chess (*Bromus rubens*), another annual grass, is becoming established in the mid-elevations. Russian thistle (*Salsola iberica* and *S. paulsennii*) appears in areas where the native vegetation has been removed and the soil composition has changed (DOE/NV 1991b, 1988; ERDA 1976).

Like vegetation, animals on the NTS are representative of both the Mojave Desert and the Great Basin and the associated transition zone. There are over 30 species of reptiles and amphibians, 190 species of birds, and 50 species of mammals on the NTS (DOE/NV 1993b;

ERDA 1976). Many animals utilize man-made reservoirs and natural springs and seeps on the NTS. Sewage ponds have also become an important resource for wildlife.

Reptiles and amphibians on the NTS include 1 species of desert tortoise, 14 species of lizards, and 17 species of snakes. In addition, the NTS is within the range of the Great Basin spadefoot toad (*Scaphiopus intermontanus*), but this amphibian has not been identified on the NTS (DOE/NV 1993b; ERDA 1976; Medica 1990).

Birds on the NTS are often migratory and seasonal residents. The most widely distributed species include the black-throated sparrow (*Amphispiza bilineata*), house finch (*Carpodacus mexicanus*), red-tailed hawk (*Buteo jamaicensis*), common raven (*Corvus corax*), loggerhead shrike (*Lanius ludovicianus*), mockingbird (*Mimus polyglottos*), ash-throated flycatcher (*Myiarchus cinerascens*), and mourning dove (*Zenaida macroura*) (DOE/NV 1993b; ERDA 1976; Greger 1991).

The most abundant group of mammals on the NTS are rodents. Carnivores include coyote (*Canis latrans*), kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), bobcat (*Lynx rufus*), mountain lion (*Felis concolor*) and long-tailed weasel (*Mustella frenata*). Large mammals on NTS include the mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), desert big horn sheep (*Ovis canadensis*), and wild horse (*Equus caballus*). Hunting, grazing, and fishing are not allowed on the NTS (DOE/NV 1993b, 1986b; ERDA 1976; Medica and Saethre 1990).

In general, the portion of Frenchman Flat in Area 5 (i.e., north and east of Mercury Highway) within which the proposed SNF facility would be located is within the creosote bush community. This plant community is characteristic of the Mojave Desert. Pre-activity surveys completed for the Radioactive Waste Management Site, which is in the general area of the proposed SNF facility, found the dominant vegetation to include creosote bush, spiny hopsage, white bursage, desert thorn, and Nevada joint-fir (*Ephreda nevadensis*) (EG&G 1993, 1991, 1990, 1989).

The distribution of animals within the portion of Area 5 being considered for the proposed SNF facility is not as well documented as for the rest of the NTS. However, species identified within 5 kilometers (3.1 miles) of the Liquefied Gaseous Fuels Spill Test Facility include 8 reptiles, 17 bird species, and 14 mammals (Hunter et al. 1991). The Liquified Gaseous Fuels Spill Test Facility is located within similar habitat approximately 7.6 kilometers (5 miles) south of the proposed facility. There are no water sources located within the portion of Area 5 being considered for the proposed SNF facility.

4.9.2 Wetlands

There are several natural springs on the NTS that feed flowing streams (Greger and Romney nda). Some of these extend for 91 meters (300 feet) before infiltration and evaporation cause them to dry up. Vegetation along these channels consists of willow (*Salix* sp.) and tamarisk (*Tamarix* sp.). Reservoirs on the site which are fed by groundwater from wells have developed wetland vegetation such as tamarisk, cattail (*Typha* sp.), and bulrushes (*Scirpus* sp.) (Elle 1992). A wetland delineation, as defined by the 1987 U.S. Army Corps of Engineers wetlands Delineation Manual (U.S. COE 1987), has not been performed for any of these areas (DOE/NV 1993b; Elle 1992), and National Wetlands Inventory maps are not available for the NTS.

The portion of Area 5 under consideration for the SNF facility does not have any known springs, seeps, or wetland vegetation (DOE/NV 1993b; Greger and Romney nda).

4.9.3 Aquatic Resources

Potential aquatic habitat on the NTS includes surface drainages, playas, man-made reservoirs, and springs. Permanent surface water sources are limited to a few small springs.

There are two dry lake beds (playas) located in the eastern (Yucca Flat) and southeastern (Frenchman Flat) portions of the NTS. Runoff from the eastern half of the NTS flows through surface drainages to onsite playas and can collect for a few days to a few months. The remaining areas of the NTS drain offsite via arroyos and dry stream beds that carry water only during intense or persistent rainstorms. These surface drainages and playas are unable to support permanent fish populations (ERDA 1976; Greger and Romney nda).

Reservoirs resulting from discharge of well water located on the NTS support three introduced species of fish: bluegill (*Lepomis macrochirus*), goldfish (*Carassius auratus*), and golden shiner (*Notemigonus crysoleucas*). Springs located throughout the site do not support fish populations (Elle 1992). There are no springs, seeps, or other permanent water bodies on the proposed SNF Site; however Cane Spring is located in Area 5, southwest of the proposed SNF Site (Greger and Romney nda).

4.9.4 Threatened and Endangered Species

Table 4.9-1 presents a list of federally and state-listed species that may be found in the vicinity of NTS.

There are no known plants which have been listed as threatened or endangered under the Endangered Species Act (16 USC 1531-1534) on NTS. However, the U.S. Fish and Wildlife Service has identified candidate species for listing, 11 of which may occur on or in the vicinity of the NTS. Ten of these are Candidate Category 2 species, meaning that information indicates that they may be appropriate for listing as endangered or threatened but more information is needed. One species, the Beatley milk-vetch, is a Candidate Category 1 species (DOE/NV 1993b, 1991c; EG&G 1993; USAF et al. 1991). This species has been identified on Pahute Mesa (Hunter et al. 1988). A Candidate Category 1 species is one for which there is substantial information indicating that it is appropriate for listing as endangered or threatened Four Candidate Category 2 species (camissona, black wooly-pod, cymopterus, and Beatley phacelia) have been identified in Frenchman Flat, although none of these was identified during surveys conducted near the proposed SNF facility site (EG&G 1993; Tetratech 1993).

Two listed reptile species on or in the vicinity of NTS are of concern. The chuckwalla is a Federal Candidate Category 2 species which may occur on NTS. The desert tortoise is the only federally listed threatened species known to occur on NTS (DOE/NV 1993b; EG&G 1993). Both the desert tortoise and the chuckwalla are listed as reptile species of Frenchman Flat (DOE/NV 1986b).

Table 4.9-1. Federally and state-listed threatened, endangered, and other special status species that may be found in the vicinity of the Nevada Test Site.[a]

Common name	Scientific name	Status[b] Fed.	State
	Plants		
Amargosa penstemon	*Penstemon fruticiformis* ssp. *amargosae*	C2	NL
Beardtongue[c]	*Penstemon pahutensis*	C2	NL
Beatley milkvetch[c]	*Astragalus beatleyae*	C1	CE
Beatley phacelia[c]	*Phacelia beatleyae*	C2	NL
Black wooly-pod[c]	*Astragalus funerus*	C2	NL
Camissonia[c]	*Camissonia megalantha*	C2	NL
Cymopterus[c]	*Cymopterus ripleyi* var. *saniculoides*	C2	NL
Green-gentian[c]	*Frasera pahutensis*	C2	NL
Kingston bedstraw[c]	*Galium hilendiae* ssp. *kingstonense*	C2	NL
Mojave fishook cactus[c]	*Sclerocactus polyancistrus*	NL	CY
White bear desert-poppy[c]	*Arctomecon merriamii*	C2	NL
	Birds		
Bald eagle[d]	*Haliaeetus leucoephalus*	E	E
Golden eagle[c]	*Aquila chrysaetos*	NL	P
Ferruginous hawk[c]	*Buteo regalis*	C2	NL
Loggerhead shrike[c]	*Lanius ludovicianus*	C2	NL
Mountain plover[c]	*Charadrius montanus*	C2	NL
Peregrine falcon[d,e]	*Falco peregrinus*	E	E
Western least bittern	*Ixobrychus exilis hesperis*	C2	NL
Western snowy plover[c]	*Charadrius alexandrinus nivosus*	C2	NL
White-faced ibis[c]	*Plegadis chihi*	C2	NL
	Reptiles		
Chuckwalla	*Sauromalus obesus*	C2	NL
Desert tortoise[c]	*Gopherus agassizii*	T	T
	Mammals		
Spotted bat	*Euderma maculatum*	C2	NL
Pygmy rabbit	*Branchylqus idahoensis*	C2	NL
	Fish		
Devils Hole pupfish[d,f]	*Cyprinodon diabolis*	E	E

a. Sources: CFR (1993c,d); ERDA (1976); EG&G (1993); DOE/NV (1986b); FR (1991, 1990b); FWS (1993); Hunter et al. (1988); NV DCNR (1992); Tetratech (1993).

b. Status codes:
C1 Federal candidate - Category 1 (probably appropriate to list)
C2 Federal candidate - Category 2 (possibly appropriate to list more study required)
CE State critically endangered by authority of NRS 527.270 (State Division of Forestry)
CY State protected by authority of NRS 527.60-.120 under the Nevada Cacti and Yucca Law
E Endangered
NL Not listed
T Threatened
P State protected by NAC 503.050

c. Species recorded on the NTS.

d. U.S. Fish and Wildlife Service Recovery Plan exists for this species.

e. Peregrine falcon seen on the NTS; however not identified to subspecies level.

f. Only known location of this species is outside the NTS 24 miles (39 km) southwest of Mercury. This species is included here due to potential offsite groundwater impacts.

Note: Nevada Department of Wildlife utilizes the Federal threatened and endangered species list.

The distribution and abundance of the desert tortoise have been extensively researched; the latest research for the NTS as a whole was completed in 1991 (DOE/NV 1991c). A biological opinion from the U.S. Fish and Wildlife Service was completed in 1992 for NTS activities planned for 1992 through 1995 (FWS 1992). The desert tortoise is known to exist in the southern portion of the NTS, but its abundance on the NTS is considered to be very low to low (DOE/NV 1991c). The northern extent of its range is from Massachusetts Mountain through Control Point Hills and Mid Valley to Topopah Valley and west to the NTS boundary (DOE/NV 1991c).

Two bird species which could occur on or within the vicinity of NTS are federally listed endangered species. These are the American peregrine falcon and the bald eagle. The American peregrine falcon has been sighted on the NTS in the past but not recently (DOE/NV 1991c; ERDA 1976). Bald eagles may also occur on the NTS, but sightings have not been reported in recent literature (DOE/NV 1986b; EG&G 1993; ERDA 1976; Hunter et al. 1991). Six other bird species, all of which are Federal Candidate Category 2 species, are known to occur on or within the vicinity of NTS (DOE/NV 1991c; EG&G 1993). Recent surveys of Area 5 (which contains the proposed SNF Site) have not identified any of these species (DOE/NV 1986b; EG&G 1993, 1991, 1990, 1989). However, birds listed as common to Frenchman Flat include the golden eagle and loggerhead shrike (DOE/NV 1986b; Tetratech 1993).

There are two Federal Candidate Category 2 mammal species identified as potentially occurring in the vicinity of the NTS. Neither the spotted bat nor the pygmy rabbit has been observed during recent pre-activity surveys for the area (EG&G 1993; USAF 1993). They are also not listed as mammals occurring in Frenchman Flat (DOE/NV 1986b; Tetratech 1993).

There are no known fish species indigenous to the NTS. However, it is important to note that the only known location of the Devils Hole pupfish, a federally listed endangered species, is approximately 39 kilometers (24 miles) southwest of the NTS. The decline of this species has been attributed to low water levels caused by decreasing groundwater levels (ERDA 1977; USAF et al. 1991).

Pre-activity surveys for threatened and endangered species have recently been completed for the Radioactive Waste Management Site located in Area 5 near the proposed SNF facility. The primary purpose of these surveys was to identify live tortoise, scat, burrows, and remains. Although these surveys have found few tortoise or their sign, each new activity on NTS must undergo pre-activity surveys for the desert tortoise (DOE/NV 1991c; EG&G 1993, 1991). In addition, these surveys look for other listed species. Recent surveys have not identified any other listed or candidate species in the portion of Area 5 surrounding the Radioactive Waste Management Site, which is near the proposed SNF Site (EG&G 1993, 1991).

4.10 Noise

The major noise sources at the NTS occur primarily in developed operational areas and include various facilities, equipment and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles), aircraft operations, and testing. No NTS environmental noise survey data are available. At the NTS boundary, away from most facilities, noise from most sources is barely distinguishable from background noise levels. Some disturbance of wildlife activities might occur within the NTS as a result of operational activities and construction activities.

Existing NTS-related noise sources of importance to the public are those from transportation of people and materials to and from the NTS. These sources include trucks, buses, private vehicles, helicopters, and airplanes. In addition, some air cargo and business travel via commercial air transport through the McCarren International Airport in Las Vegas can be attributed to the NTS operations.

The State of Nevada and Nye County have not established any regulations that specify acceptable community noise levels with the exception of prohibitions on nuisance noise.

During a normal week, about 3,300 employees travel to the NTS each day. Most employees commute using the contracted bus service and a small portion commute in government or private vehicles. Both government-owned and private trucks pick up and deliver materials at the site. Most of the private vehicles, buses, and trucks travel to and from the site each day using U.S.

Route 95. The contribution of the NTS operations to traffic volumes along U.S. Route 95, especially during peak traffic periods, affects noise levels at residences along this route.

4.11 Traffic and Transportation

Traffic congestion is measured by level of service. Level of Service A represents free flow of traffic. Level of Service B is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Level of Service C is in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. Level of Service D represents high-density but stable flow. Level of Service E represents operating conditions at or near the capacity level. Level of Service F is used to define forced or breakdown of flow of traffic. The calculated Level of Service are for discrete locations along a segment. Level of Service will most likely be worse in urban areas and better in rural areas along with the segment.

The Region of Influence for the following analysis includes site roads and regional roads in Nye and Clark counties.

Vehicular access to the NTS is provided by U.S. Route 95 to the south, with off-road access to the northeast provided via Nevada State Route 375. Baseline traffic along segments providing access to the NTS contributes to differing service level conditions. Nevada State Route 375 and U.S. Route 95 are projected to remain at Level of Service A. No major improvements are presently scheduled for those segments providing immediate access to the NTS (NDOT 1992). Regional roads and local roads providing access to NTS are presented in Figures 2.1-1 and 2.1-2, respectively.

Future background traffic (defined as all future traffic not attributable to the proposed SNF facilities) is projected to contribute to differing service-level conditions for local roads in 2001. The year 2001 was selected for analysis because that is when the impacts from the proposed SNF facilities would be highest. All local and regional roads are projected to operate at Level of Service A.

The Level of Service was calculated using average daily traffic counts (NDOT 1992) and standard parameters (ITE 1991; Rand McNally 1993; TRB 1985).

The public transit serves the heavily populated regions of Clark County. Contract buses run to the NTS. There is no public transportation system serving the NTS; however, approximately 70 buses a day transport employees to and from the site. The nearest major railroad is the Union Pacific, located approximately 50 miles (80 kilometers) east of the NTS. A 9-mile (15-kilometer) standard-gauge railroad serves Area 25 of the NTS but does not connect with the Union Pacific (ERDA 1977). No navigable waterways within the Region of Influence are capable of accommodating waterborne transportation of material shipments to the NTS.

McCarran International Airport in Las Vegas provides jet air passenger and cargo service from both national and local carriers. It is outside the Region of Influence. Smaller private airports are located throughout the Region of Influence. Desert Rock Airstrip, the onsite airport, is located near Mercury.

4.12 Occupational and Public Health and Safety

Health impacts to the public from activities on the NTS are minimal as a result of administrative and design controls to minimize releases of pollutants to the environment and to achieve compliance with permit requirements, e.g., air emissions and National Pollutant Discharge Elimination System permit requirements. The effectiveness of these controls is verified through the use of monitoring and inspections. Health impacts to the public may occur during normal operations at the NTS via inhalation of air containing radioactive and chemical pollutants released to the atmosphere, immersion in this air, and ingestion of food contaminated by these pollutants. Risks to public health from other possible pathways such as exposure to contaminated soil are low relative to these pathways.

Health impacts to NTS workers during normal operations may include those from inhalation of the workplace atmosphere, consumption of potable water, direct exposure, and possible other contact with hazardous materials associated with work assignments. The potential for health impacts varies from facility to facility and from worker to worker, and available information is not

sufficient to allow a meaningful estimation and summation of these impacts. However, workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. NTS workers are also protected by occupational standards that limit atmospheric and drinking water concentrations of potentially hazardous chemicals and that also limit radiation exposure. Monitoring ensures that these standards are not exceeded. Additionally, DOE requirements (DOE Order 3790.1B) ensure that conditions in the workplace are as free as possible from recognized hazards that cause or are likely to cause illness or physical harm. Therefore, worker health conditions at the NTS are expected to be substantially better than required by standards.

Health effects from radiation are presented here as the risk of fatal cancer. This risk is in the ratio of the health risk estimator (risk of fatal cancer per rem of exposure). The value of this estimator for exposures to the public is 5.0×10^{-4} for fatal cancers. The corresponding estimator for exposures to workers is 4.0×10^{-4}.

The DOE Nevada Field Office published a Waste Minimization and Pollution Prevention Awareness Plan in June 1991 to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at DOE/NV facilities. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All DOE/NV contractors and NTS users that exceed the EPA criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs that are implemented by the DOE/NV plan. Contractor programs ensure that waste minimization activities are in accordance with Federal, state, and local environmental laws and regulations, and DOE Orders (DOE/NV 1993c).

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of wastes generated, and implementation of recycling programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor and NTS user has been established to coordinate DOE/NV waste minimization and pollution awareness activities (DOE/NV 1993c).

4.12.1 Doses

4.12.1.1 Radiological Doses. Every individual is affected by natural and other background radiation. The major sources of background radiation exposure to individuals in the vicinity of the NTS are shown in Figure 4.7-2. All annual doses to individuals from background radiation are expected to remain constant over time.

Releases of radionuclides to the environment from NTS operations provide another source of radiation exposure to people in the vicinity of the NTS. Table 4.7-2 summarizes the airborne radionuclides and quantities released in curies during baseline NTS operations. The annual committed doses to the public resulting from these release are given in Table 4.7-4. Compared to those from natural background radiation, these doses are very small. The doses are all less than 1 percent of the most restrictive standard given in DOE Order 5400.5.

Workers at the NTS receive the same dose as the general population from background radiation but also receive an additional dose from working in the facilities. The doses to the average and maximally exposed workers due to operation in 1991 (assumed representative of 1995 operations), were approximately 5 and 500 millirem, respectively; the total dose to all workers was about 4 person-rem (DOE/NV 1992c). The maximum dose is well within the limit of 5,000 millirem per year specified in DOE Order 5480.11 and in 10 CFR 835.

4.12.1.2 Nonradiological Doses. Every individual is also affected by background concentration of nonradiological pollutants. The maximum background concentrations for those criteria pollutants which have been measured is provided in Table 4.7-5. The maximum existing DOE site contribution concentration was then computed, as discussed in Section 4.7.

4.12.2 Health Effects

4.12.2.1 Radiological. The fatal cancer risk to the maximally exposed member of the public due to the radiological emissions from NTS baseline operations in 1995 would be 5.5×10^{-9}. The same risk estimator projects 2.6×10^{-6} excess fatal cancer to the population within

80 kilometers (50 miles) of the NTS. These values would be approximately 2.2×10^{-7} and 1×10^{-4}, respectively, during the 40 years of SNF facility operations.

Because of the different age distribution of a working population, the health risk estimators for workers are somewhat lower than for members of the general public. As a result of 1995 baseline operations at the NTS, these estimators predict a fatal cancer risk of 2.0×10^{-4} to the maximally exposed worker, and 1.6×10^{-3} excess fatal cancer among all workers. The risk faced by an average worker would be 2.0×10^{-6}. Over the 40-year operating life of the proposed SNF facility, and assuming a particular worker during this time, these values would be 8.0×10^{-3}, 6.4×10^{-2}, and 8.0×10^{-5}, respectively.

4.12.2.2 Nonradiological. As discussed in Section 4.7, the maximum existing DOE site contribution of criteria nonradiological air pollutants were computed. In Table 4.7-5 the total existing maximum concentration (which adds the maximum existing DOE site contribution to the maximum background concentration) is presented. The total existing maximum concentration values represent the highest concentrations to which members of the public would be exposed. In every case where information was available, the highest concentration was less than the applicable health-based standard.

4.12.2.3 Health Effects Studies. The epidemiologic studies concerning the NTS have concentrated on the health effects in soldiers and children associated with nuclear testing rather than on plant emissions (Beck and Krey 1983; Bross and Bross 1987; Caldwell et al. 1980; Lyon et al. 1979; Rallison et al. 1990; and others). The results regarding the observed leukemia incidence and deaths in exposed children are contradictory, with some studies reporting an excess and others reporting no excess. The validity of the analytical methods used in some of these studies are subject to various opinions. For soldiers, the results regarding leukemia and polycythemia vera differed between two studies relating to nuclear test explosions, but reanalyses showed leukemia, respiratory, and other cancers to be associated only with exposure to higher doses, e.g., more than 300 millirem for leukemia cases.

In March 1990, the Secretary of Energy announced that DOE would turn over responsibility for analytical epidemiologic research on long-term health effects on workers at DOE facilities and surrounding communities to the Department of Health and Human Services and directed that worker health and exposure data be released. A Memorandum of Agreement with the Department of Health and Human Services was signed in January 1991. The Department of Health and Human Services is now conducting the ongoing health effects research program. To develop a data base on workers, DOE has initiated an Epidemiologic Surveillance Program and a Health-Related Records Inventory.

4.13 Utilities and Energy

4.13.1 Water Consumption

There are 14 active wells which supply water to the NTS. Figure 4.8-2 in Section 4.8 shows the location of these wells. These 14 wells combined had a capacity of 387 liters per second (6,139 gallons per minute) in 1993 (DOE/NV 1993a). From 1988 to 1993, water use at the NTS varied from a high of 134 liters per second (2,125 gallons per minute) in 1989 to a low of 60 liters per second (949 gallons per minute) in 1993 (DOE/NV 1994c; Leppert 1993). Water usage projections to 1995 are unavailable; however, significant changes in the water consumption level are not anticipated.

There are also a number of deactivated wells located on the NTS. These wells could add additional water supply capacity if they were reactivated (Leppert 1993). It has been estimated that the activation of these wells could increase the available water supply by 85 liters per second (1,342 gallons per minute). Other methods to increase production of water could include increasing pump sizes or installing new wells (DOE/NV 1993a).

The proposed SNF site would be located in Area 5. There are four wells located in Area 5, two of which supply potable water. These two wells have a capacity of 38 liters per second (595 gallons per minute) (DOE/NV 1994c; 1993b). A third well in the area is currently being used to supply water for construction activities. The fourth well has been deactivated (DOE/NV 1993b). In 1993, Area 5 used approximately 12 liters per second (191 gallons per minute) of water, including the well used for construction purposes. Water usage for Area 5 is not expected to change substantially from 1993 to 1995 (DOE/NV 1994c; Leppert 1994).

4.13.2 Electrical Consumption

The NTS obtains electrical power from the Nevada Power Company and Valley Electric Association. Each company provides an independent 138 kilovolt transmission line to the site. The capacity of these transmission lines, with scheduled upgrades, is approximately 40 to 45 megavolt-amperes. The local utilities' 138 kilovolt transmission grids have adequate capacity within a 80-kilometer (50-mile) radius of the NTS to serve an additional 75 megavolt-amperes of load. In addition, the local utilities' proposed expansion of their existing 230 kilovolt transmission systems would make capacity in excess of 200 megavolt-amperes available within an 80-kilometer (50-mile) radius (DOE/NV 1993a).

From 1989 to 1993, the annual consumption of electricity ranged from a high of 183,118 megawatt hours in 1989 to a low of 144,521.5 megawatt hours in 1993. The peak demand varied from a high of 38.4 megavolt-amperes in 1989 to a low of 30.9 megavolt-amperes in 1993 (Leppert 1993; Thornton 1994). In 1995, the annual consumption of electricity is projected to be 176,440 megawatt hours, with a peak demand of 39.5 megavolt-amperes. The institution of energy management practices can regulate the peak demands of various NTS activities so that the maximum peak capacity is not exceeded. The predicted increase in overall electricity usage for 1995 is attributable to the increased requirements for the Yucca Mountain Site Characterization Project; the usage for the rest of the NTS is predicted to continue its downward trend (Thornton 1994).

The Frenchman Flat Substation, located in Area 5, has a capacity of 12.5 megavolt-amperes (Thornton 1994). A 34.5 kilovolt line from this substation feeds the loads at Area 6, Well C, the Tweezer facility, and the east side of the test areas used by LANL (DOE/NV 1993b). In 1993, the peak demand on the substation was 5.2 megavolt-amperes. This demand is not anticipated to change substantially from 1993 to 1995 (Thorton 1994).

4.13.3 Fuel Consumption

The majority of the energy used at the NTS is provided by electricity, but diesel fuel and fuel oil are used to provide heat in some facilities and backup power.

4.13.4 Wastewater Disposal

Currently, there are no wastewater disposal facilities in Area 5. Septic systems are used in parts of the NTS for sanitary wastewater disposal. These septic systems discharge to percolation/evaporation stabilization ponds. These ponds, however, are only used for the disposal of wastewater not generated by any manufacturing processes.

4.14 Materials and Waste Management

The operations conducted at the NTS have resulted in generation of low-level radioactive waste, hazardous waste, mixed waste (radioactive and hazardous combined), and sanitary waste (nonhazardous, nonradioactive solid waste). In addition, the NTS stores mixed transuranic waste received from Lawrence Livermore National Laboratory. This section discusses the treatment, storage, and disposal of waste at the NTS.

DOE currently operates two disposal facilities in Areas 3 and 5 at the NTS for low-level radioactive waste generated by DOE defense facilities. The Area 5 Radioactive Waste Management Site also serves as a interim storage area for LLNL transuranic wastes which will be shipped to the Waste Isolation Pilot Plant in New Mexico for final disposal. The Area 5 facility also accepts mixed waste, which contains both low-level radioactive waste and hazardous waste only if the waste was generated on the NTS.

All hazardous wastes generated at the NTS are disposed of offsite at commercial facilities approved and permitted by the EPA. Hazardous wastes are temporarily stored at the NTS in full compliance with Federal, state, and local requirements.

Mixed waste disposal facilities are presently operating under interim status, pending completion of the Resource Conservation and Recovery Act (RCRA) permitting process. Operation of the low-level radioactive waste and mixed waste disposal sites and the temporary transuranic waste storage site are supported by an environmental monitoring program that indicates waste is being safely contained in the near-surface environment in which it is emplaced.

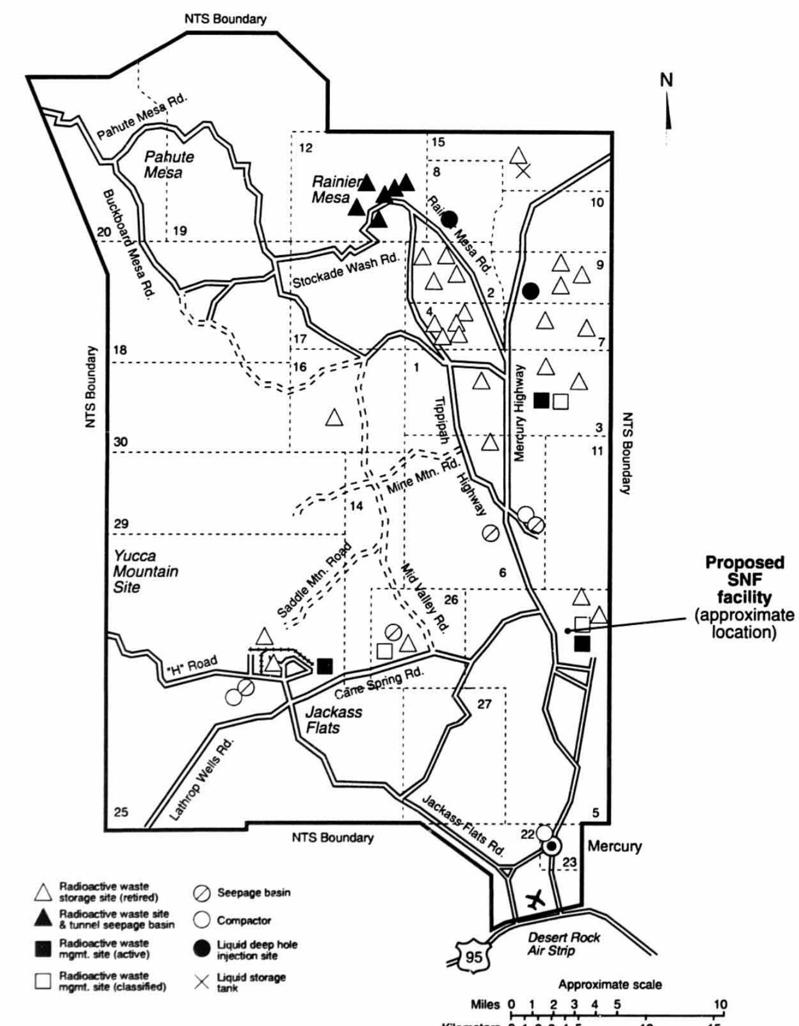
The radioactive and mixed-waste disposal facilities are mainly shallow land burial areas. Figure 4.14-1 shows the location of the waste management facilities at the NTS (DOE/NV 1993b, 1992b).

The DOE Nevada Operations Office developed and implemented a Waste Minimization and Pollution Prevention Awareness Plan to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at the NTS. The plan is designed to reduce the possible pollutant releases to the environment. The objectives of the waste minimization and pollution program are to:

- Identify processes generating waste streams
- Characterize and track each waste stream
- Identify, evaluate, and implement applicable waste minimization technologies
- Set numerical goals and schedules after the initial assessment of technological and economic feasibility
- Establish an employee pollution prevention awareness and training program.

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of wastes generated, implementation of recycling programs, and incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities and in upgrades of existing facilities.

The NTS manages the following waste categories: mixed transuranic waste, mixed low-level waste, low-level waste, hazardous waste, sanitary waste, and nonhazardous waste. The NTS does not currently manage high-level waste or SNF. The NTS waste management activities include onsite treatment, onsite storage, onsite disposal, and preparation for appropriate offsite disposal. Additionally, the NTS uses and manages an onsite inventory of hazardous materials, including



Source: DOE/NV 1993b.

Figure 4.14-1. Existing treatment, storage, and disposal units at the NTS.

some managed in underground storage tanks. Figures 4.14-2 and 4.14-3 present flow diagrams of onsite generated waste management and waste shipment, receipt, and disposal, respectively.

Waste generation rates presented for each of the waste categories for the NTS represent 1993 waste generation rates unless otherwise stated and are assumed representative of the 1995 baseline year. Table 4.14-1 presents the baseline waste management for 1995 for those waste categories currently managed at the NTS. In addition, the table presents available disposal/ storage capacity and waste disposition.

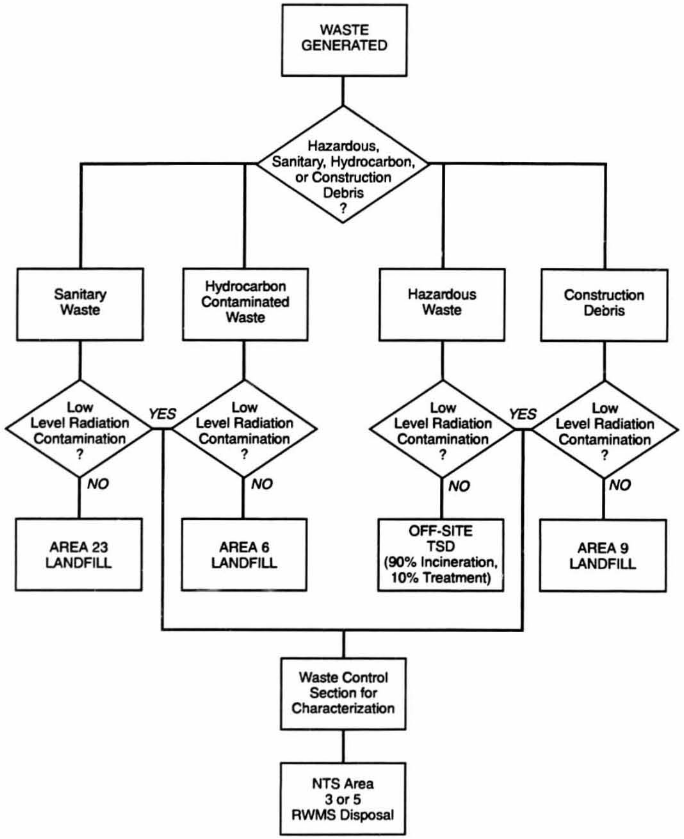
4.14.1 Transuranic Waste

Transuranic waste from the Rocky Flats Plant and mixed-transuranic waste from LLNL are stored at the NTS at the transuranic waste storage cell located in Area 5 Radioactive Waste Management Site. The transuranic waste has been characterized and repackaged, and the mixed-transuranic waste has been placed in a RCRA-permitted storage area consisting of 55-gallon drums and steel boxes stored on wooden pallets fixed upon a curbed asphalt pad. Approximately 204,663 kilograms (451,201 pounds) with a total volume of 612 cubic meters (800 cubic yards) of transuranic waste are stored at the NTS (DOE/NV 1994d). The NTS expects no additional transuranic or mixed-transuranic wastes to be stored at this unit.

4.14.2 Mixed Low-Level Wastes

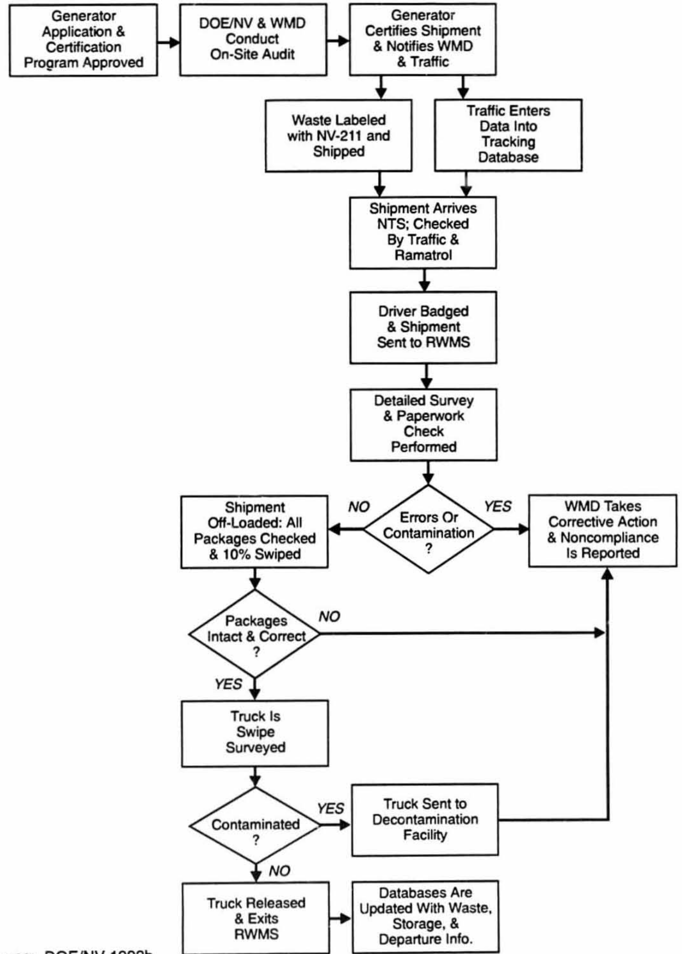
The Area 5 Radioactive Waste Management Site contains Pit 3, which is an active mixed low-level waste management unit. Pit 3 is the only active landfill cell within the Area 5 Radioactive Waste Management Site for which a RCRA permit is being sought. Pit 3 is an unlined, trapezoidal shaped pit occupying 3.42 x 10^4 square meters (8.46 acres) with a process capacity of 1.29 x 10^5 cubic meters (1.69 x 10^5 cubic yards). The estimated disposal space for mixed low-level waste remaining at this facility is 9.03 x 10^4 cubic meters (1.19 x 10^5 cubic yards) (DOE/NV 1992b).

A RCRA permit is being sought for a proposed Mixed Waste Disposal Unit in the area immediately north of Pit 3 in the Area 5 Radioactive Waste Management Site. This Mixed



Source: DOE/NV 1994c.

Figure 4.14-2. Flow diagram for waste generation at the NTS.



Source: DOE/NV 1992b.

Figure 4.14-3. Flow diagram for waste shipment, receipt, and disposal at the NTS.

Table 4.14-1. Baseline waste management for 1995 at the NTS.[a]

Waste type	Volume generated or disposed of (m^3)	Available disposal space (m^3)	Disposition
Transuranic waste and mixed-transuranic waste	0	8,296	Interim onsite storage
Low-level waste	10,845	438,359	Onsite disposal
Mixed low-level waste	0	90,240	Onsite disposal
Hazardous waste	252	91	90-day pad
Sanitary waste	1.1×10^4 [b]	c	Onsite disposal

a. Sources: DOE/NV (1994d, 1992c).

b. 1992 data.

c. Current disposal space adequate.

Waste Disposal Unit would occupy 2.1×10^5 square meters (52 acres) and consist of ten landfill cells. The estimated disposal space for mixed waste in this proposed unit is approximately 1.20×10^5 cubic meters (1.58×10^5 cubic yards) (DOE/NV 1992b).

In May 1990, mixed waste disposal operations ceased due to EPA issuance of the Land Disposal Restrictions of RCRA. Active mixed waste disposal operations will commence under interim status in Pit 3 upon completion of NEPA documentation and an approved Waste Analysis Plan (DOE/NV 1993c). No mixed low-level waste has been received, generated, or disposed of at the NTS since 1991 (DOE/NV 1994d, 1993c,f).

4.14.3 Low-Level Waste

Two low-level waste disposal facilities are in operation at the NTS: Area 5 Radioactive Waste Management Site and the Area 3 Radioactive Waste Management Site (DOE/NV 1992c). The Area 5 Radioactive Waste Management Site receives low-level waste generated at the NTS and other DOE facilities and occupies approximately 2.9 square kilometers (730 acres) of land. The waste is disposed of in large-diameter shafts, trenches, and shallow pits. The total volume of low-level waste disposed of at the Area 5 Radioactive Waste Management Site between 1961 and 1991 was 3.96×10^5 cubic meters (5.8×10^5 cubic yards). Average annual low-level waste disposal for this period was 1.3×10^4 cubic meters (1.7×10^4 cubic yards). During 1993, approximately 1.1×10^4 cubic meters (1.4×10^4 cubic yards) of low-level waste was disposed of at the NTS (DOE/NV 1994d).

4.14.4 Hazardous Waste

The primary facilities that generate or manage nonradioactive hazardous wastes and/or use or store nonradioactive hazardous materials are the Liquified Gaseous Fuels Spill Test Facility, the Hazardous Waste Accumulation Site, the tunneling facilities and operations, and various underground storage tanks.

The Liquified Gaseous Fuels Spill Test Facility is located on Frenchman Lake in Area 5. This location provides a remote, environmentally acceptable setting for atmospheric release of hazardous materials and toxic substances for investigative purposes. The facility consists of a tank farm, spill area, wind tunnel, and pads for conducting small volume spill tests. The facility also includes a control building that houses data acquisition and recording instruments, a command and control computer, and support personnel. A total of 17 spill tests were conducted at the facility in Area 5. Discharges from the test facility occur at a controlled rate and consist of a measured volume of hazardous test fluid released on a surface especially prepared to meet the test requirements. Personnel monitor and record operating data, close-in and downwind meteorological data, and downwind gaseous concentration levels. Spills involving hydrofluoric acid were conducted in 1991 and the results monitored (DOE/NV 1992c).

The Hazardous Waste Accumulation Site consists of an impervious concrete pad with 15-centimeter (6-inch) curbs to contain spillage and to protect the pad from precipitation runon and runoff; a separate curbed area is provided for noncompatible wastes. A roof protects the wastes from rain and weathering effects; there is also a fire detection system (DOE/NV 1992d). Each operating entity at NTS is a potential satellite accumulation area for hazardous waste. Each satellite accumulation area is allowed to accumulate up to 208.2 liters (55 gallons) of hazardous waste or 0.95 liter (1 quart) of acutely hazardous waste. Within 3 days of reaching these quantities, the waste is transferred to the Hazardous Waste Accumulation Site. If the material is unknown or if an offsite treatment, storage and disposal facility wishes to confirm the contents of a waste stream, samples are collected for characterization (DOE/NV 1992d).

When the waste containers are transferred to the Hazardous Waste Accumulation Site, they are checked for proper labeling and an accumulation date is assigned to each container. An EPA-permitted treatment, storage, and disposal facility is contacted prior to the 90-day storage limit to collect and remove the accumulated wastes from the NTS (DOE/NV 1992d).

Nuclear devices were tested in horizontal tunnels mined into Rainer Mesa at the NTS. The tests were conducted in zeolitized volcanic tuffs, which act as a perching layer for waters infiltrating from the mesa surface. During normal tunneling operations, fractures containing water are intercepted creating artificial springs in the tunnels. Periodically, these waters contain radionuclides from previous underground nuclear tests and are drained out of the tunnels into evaporation ponds or washes. Tunneling and related operations also may have released organic

compounds and heavy metals to the tunnel effluent. Presently, sampling of the tunnel effluent is being conducted to characterize the effluent. The objectives of the project include identifying the types and concentrations of radionuclides, metals, and organic compounds in the effluent of U12t, U12e, and U12n tunnels. Variations of discharge volumes and chemical contaminants over time are also being examined (DOE/NV 1992c).

There is a site-wide inventory of 115 underground storage tanks at the NTS. These include 24 underground storage tanks containing petroleum products that were removed, closed in place, or temporarily taken out of service in 1991 in accordance with state statutes as well as 17 underground storage tanks which were temporarily closed in 1991 while awaiting upgrades (DOE/NV 1992c).

As part of the 1991 underground storage tank activities, all tanks to be upgraded had soil samples taken from the tank ends to identify any soil contamination prior to redesign and construction. To date, overfill releases from underground storage tanks located at the Areas 6, 12, and 23 gasoline stations were observed and necessitated additional soil sampling. All underground storage tanks that were planned to be upgraded (except a tank containing asphaltic material) were also pressure tested for leaks. All tanks passed the test limit of 0.76 liter per hour (0.2 gallon per hour) (DOE/NV 1992c).

Numerous underground storage tanks have been identified throughout the site as "Undetermined Activity Status." The contents of some of these underground storage tanks is classified as "H?" which indicates that the contents are presumed to be hazardous.

The types of possible wastes found on the surface of the NTS include radionuclides, organic compounds, metals, hydrocarbons, and residues from plastic, epoxy, and drilling muds (not petroleum production related and therefore considered hazardous under Subtitle C of RCRA). A wide variety of surface facilities, such as injection wells, leach fields, sumps, waste storage facilities, tunnel ponds and muck piles, and storage tanks, may have contaminated the local soil and the shallow unsaturated zone of the NTS. Because of the great depths to groundwater and the arid climate, it is assumed that the potential for mobilization of surface and shallow subsurface contamination is minimal. However, contaminants entering carbonate bedrock from

Rainier Mesa tunnel ponds, contaminated wastes injected into deep wells, and wastes disposed into subsurface craters have the potential to reach the regional water table. Pilot wells were to be installed during 1992 to support the RCRA permitting process (DOE/NV 1992c).

Annual generation or disposal of hazardous waste at the NTS was approximately 252 cubic meters (329.6 cubic yards) during 1993. Available storage space on the 90-day pad is approximately 91 cubic meters (119 cubic yards) (DOE/NV 1994d).

4.14.5 Sanitary Waste

Sanitary wastes are expected to be generated at the current rates for several years into the future, then decline assuming the present moratorium on underground weapons testing. Liquid sanitary wastes are disposed of in septic tanks/leach fields, sumps, or in ponds, and solid sanitary wastes are disposed of in landfills at various locations on the site. The NTS currently maintains 13 sewage discharge permits: Area 2, Area 6 (5), Area 22, Area 23, Area 25 (4), and Area 12 (DOE/NV 1993c). Approximately 9.1×10^3 cubic meters (11,902 cubic yards) of sanitary waste were generated at the NTS during 1991 and 1.1×10^4 cubic meters (14,388 cubic yards) during 1992 (DOE/NV 1993c). Sufficient disposal space is available at the NTS for current needs.

4.14.6 Hazardous Materials

Polychlorinated biphenyls, pesticides, and asbestos have been or currently are managed at the NTS. These wastes and materials are managed in addition to the approximately 90,000 kilograms (100 tons) of RCRA-regulated nonradioactive hazardous wastes generated annually at the NTS, the approximately 218,000 kilograms (240 tons) of non-RCRA-regulated hazardous waste generated annually at the NTS, and the wastes and materials managed at the facilities discussed previously.

By the end of 1991, all known polychlorinated biphenyl transformers and other electrical equipment had been either reclassified or appropriately disposed of, and three polychlorinated biphenyl-contaminated transformers and regulators were under the 90-day period for reclassification. Successful reclassification of these three polychlorinated biphenyl-contaminated

transformers will complete the reclassification or disposal of all known polychlorinated biphenyl and polychlorinated biphenyl contaminated transformers at the NTS (DOE/NV 1992c).

No unusual environmental activities relating to the Federal Insecticide, Fungicide, and Rodenticide Act occurred in 1991 at the NTS. Pesticides are stored in an approved storage facility located in Area 23. Pesticide usage includes insecticides, herbicides, and rodenticides. Insecticides are applied twice a month at the food service areas, herbicides are applied once a year, and all other pesticides are applied on an as-requested basis. General-use pesticides are used for most applications, although restricted-use herbicides and rodenticides are used on occasion (DOE/NV 1992c).

The Area 11 Explosive Ordnance Disposal Facility is a thermal treatment unit for disposal of conventional explosives. Explosives detonated at the facility include Defense Nuclear Agency materials and waste explosives from Reynolds Electrical and Engineering Co., Inc. tunnel operations, the Wackenhut Firing Range (used by the NTS security force), and the resident national laboratories. No radioactive or radioactive-contaminated materials are accepted or detonated at the Area 11 Explosive Ordnance Disposal unit.

The unit encompasses approximately 0.08 square kilometer (20 acres) of land located between Frenchman Flat and Yucca Flat, with four graded areas. Only one of these graded areas is used for detonation. Magazines are used to store detonation materials and waste explosives. Approximately 80 to 90 percent of the explosives detonated at the Explosive Ordnance Disposal unit during the past 10 to 12 years have been water-gel explosives; earlier, the primary waste was gelatin-based dynamite. Other explosives detonated include small amounts of trinitrotoluene (TNT), RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) pellets, small arms ammunition (from past military operations at NTS), and black powder (DOE/NV 1992b).

4.14.7 Non-hazardous Waste

Solid wastes are regulated through State of Nevada regulations NAC 444 and Federal regulations 40 CFR 241, 257, and 258. Solid wastes generated include used petroleum products, uncontaminated tunnel muck, drilling fluids, cement and grout wastes, construction debris, refuse, sludge from wastewater lagoons, septic tank and chemical toilet sludge, and animal carcasses. The NTS has several sanitary landfills and construction landfills in operation; several landfills have been closed or abandoned (DOE 1990).

Some wastes not regulated under RCRA will be stored at the Hazardous Waste Accumulation Site. These nonregulated wastes are shipped offsite along with the RCRA wastes to a treatment, storage, and disposal facility. Only non-RCRA hazardous wastes that cannot be disposed of at the NTS landfill will be stored at the Hazardous Waste Accumulation Site for offsite shipment. Any drum containing nonregulated wastes will carry a label so specifying. The contents of the drum will be entered on a space provided on the label. Wastes in this category include but are not limited to epoxies, photochemicals, spent antifreeze, and oils and solvents that do not carry EPA codes.

Recycling of paper, metals, glass, plastics, and cardboard has already resulted in some decrease in quantities of waste and is expected to result in significant decreases over the next few years (DOE/NV 1992b).

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5. ENVIRONMENTAL CONSEQUENCES

5.1 Overview

This chapter describes the potential environmental consequences from the construction and operation of spent nuclear fuel (SNF) facilities at the Nevada Test Site (NTS) under the Centralization and Regionalization Alternatives. Potential environmental consequences are assessed to the extent necessary to support a programmatic decision concerning the siting of the proposed SNF facilities. More detailed considerations of potential environmental consequences would be performed as necessary prior to initiating construction or operation of the facilities.

5.2 Land Use

5.2.1 Centralization Alternative

Construction and operation of SNF facilities under this alternative would require the disturbance of approximately 90 acres (0.36 square kilometer), including buffer areas. Use of the proposed SNF site for program activities would be consistent with existing nearby land uses and land use policies and plans. The current land use designations for this area are Low-Level Waste Facility Management and Buffer/Reserved Area. Use of this area for program activities would also be consistent with future land use plans (DOE/NV 1993a).

Use of the proposed site for the construction and operation of SNF facilities could result in irreversible or irretrievable land use impacts in those areas currently under Buffer/Reserved use. However, the placement of SNF facilities at this location would be consistent with DOE's 1994 draft future land use plan, which designates this portion of Area 5 as a Non-Nuclear Test Area (DOE/NV 1993a). Therefore, no mitigation measures are proposed.

5.2.2 Regionalization Alternative

As under the Centralization Alternative, use of the proposed site for construction and operation of SNF facilities under the Regionalization Alternative would be consistent with existing land uses and with all applicable land use policies and plans. Impacts would be similar in character to those described for the Centralization Alternative, except that there could be reduced land requirements under this alternative.

5.3 Socioeconomics

Socioeconomics as addressed in this Programmatic Environmental Impact Statement (PEIS) encompasses the interaction of economic, demographic, and social conditions. Economic consequences (e.g., capital requirements to support SNF research and development activities) affect business activities, market structures, procurement methods, and dissemination of commodities within and between regions. Demographic consequences (e.g., in-migration of specialized human resources to support the SNF Management Program) affect size, distribution, and composition of the population, labor force, and the housing market in the regions. Social consequences (e.g., capacity modifications of public infrastructure to support SNF activity) affect the overall quality of life enjoyed by the residents of a community (Murdock and Leistritz 1979). These conditions are potentially affected either directly or indirectly by actions proposed under the U.S. Department of Energy (DOE) SNF Management Program.

The importance of actions is relative to the affected region. A region can be described as a dynamic socioeconomic system, where physical and human resources, technology, social and economic institutions, and natural resources interrelate to create new products, processes, and services to meet consumer demands. The measure of a region's ability to support these demands depends on its ability to respond to changing economic, demographic, and social conditions.

Potential socioeconomic effects are addressed only to the extent that they are interrelated with the natural or physical environment. Direct effects include those impacts that are caused by the action and occur at the same time and place. Indirect effects include those impacts caused by the action that are later in time or farther removed in distance but still are reasonably foreseeable (i.e., offsite) (CFR 1993e). Direct and indirect effects are presented quantitatively from 1995 through 2005, and qualitatively through 2035.

Socioeconomic effects are quantified for regional economic activity and population. Other potential socioeconomic impacts to individual communities, such as public infrastructure and housing, are discussed qualitatively to address programmatic issues.

Economic impact projections include direct and indirect jobs. Direct jobs are those jobs needed to construct or support the operation of the SNF management complex at the NTS. Indirect jobs are created throughout the regional economy within the Region of Influence as a result of procurement for materials, services, and other commodities, and induced effects from consumer spending. These direct and indirect impacts reflect both construction and operation phase demands, which may occur concurrently or independently throughout the project planning period. Indirect jobs were projected using parameters from the U.S. Bureau of Economic Analysis Regional Input-Output Modeling System.

Two scenarios were analyzed to account for two potential distributions of the SNF facility construction efforts. The construction effort consists of fabricating various structures, each with its own construction labor need and a duration of either three or five years. The Peak Scenario accelerates the construction labor requirements into the first two years of construction. The Average Scenario averages the labor requirements of a structure for the duration of construction. The total construction effort for all structures, in labor years, is the same for each scenario. Therefore, for structures with a three year construction duration, the Peak Scenario has high labor needs for the first two years and then a substantial reduction for the third year, while the Average Scenario has a constant labor requirement for the three years. Likewise, for structures with a five year construction duration, the Peak Scenario has a high labor need for the first two years, then a lower need for the remaining three years, while the Average Scenario has a constant requirement for all five years. Because the total construction labor years for each structure is the same for both scenarios, the Average Scenario will have a lower requirement than the Peak Scenario in the first two years, then will have a higher requirement then the Peak Scenario in the remaining construction years.

Regional population projections reflect the potential change in population resulting from an increase in regional economic activity. Detailed assumptions regarding in-migration associated with the SNF Management Program were not developed, given the programmatic scope of this analysis. Potential in-migration effects resulting from direct job creation are presented qualitatively where appropriate.

5.3.1 Centralization Alternative

The upper and lower bounds of construction and operation-related jobs generated by SNF facilities for both scenarios under the Centralization Alternative from 1995 to 2005 are illustrated in Figure 5.3-1 and tabulated in Table 5.3-1. In its initial phase, the Centralization Alternative may create 54 jobs (25 direct, 29 indirect) over a 5-year period beginning in 1995 and continuing through the year 1999 to support project planning, engineering design, personnel operations training, and environmental permitting and compliance. Construction is expected to begin in the year 2000, requiring a total of 4,351 direct jobs (5,041 indirect jobs). In that year and 2001, the Peak Scenario requires 1,587 construction laborers, while the Average Scenario needs 1,346. There is no operational labor required for this time period. In 2002, after two years of construction, the Peak Scenario decreases its construction labor requirements to 928 workers, while the Average Scenario maintains its 1,346 laborers. Additionally, 300 operational personnel are needed, raising the total of SNF workers to 1,228 for the Peak Scenario and 1,646 for the Average Scenario. By 2003, the buildings with three year construction durations have been completed; therefore, both the Peak and Average Scenario construction labor requirements decline to 125 and 157, respectively. Operation labor requirements remain at 300 workers. Total SNF labor requirements are 425 workers for the Peak Scenario and 457 for the Average Scenario. In 2004, construction labor needs for both scenarios remains at their previous level, but operational personnel increase. Total SNF labor requirements are 612 workers in the Peak Scenario and 644 workers in the Average Scenario. By 2005, all construction has been completed and operational personnel have increased to the full staff labor requirement of 800 workers.

The Peak Scenario reaches its maximum construction labor with 1,587 direct jobs (3,426 total jobs created) over a 2-year period from years 2000 through 2001. The Average Scenario would have its maximum construction labor with 1.346 direct jobs (2,906 total jobs created) in a

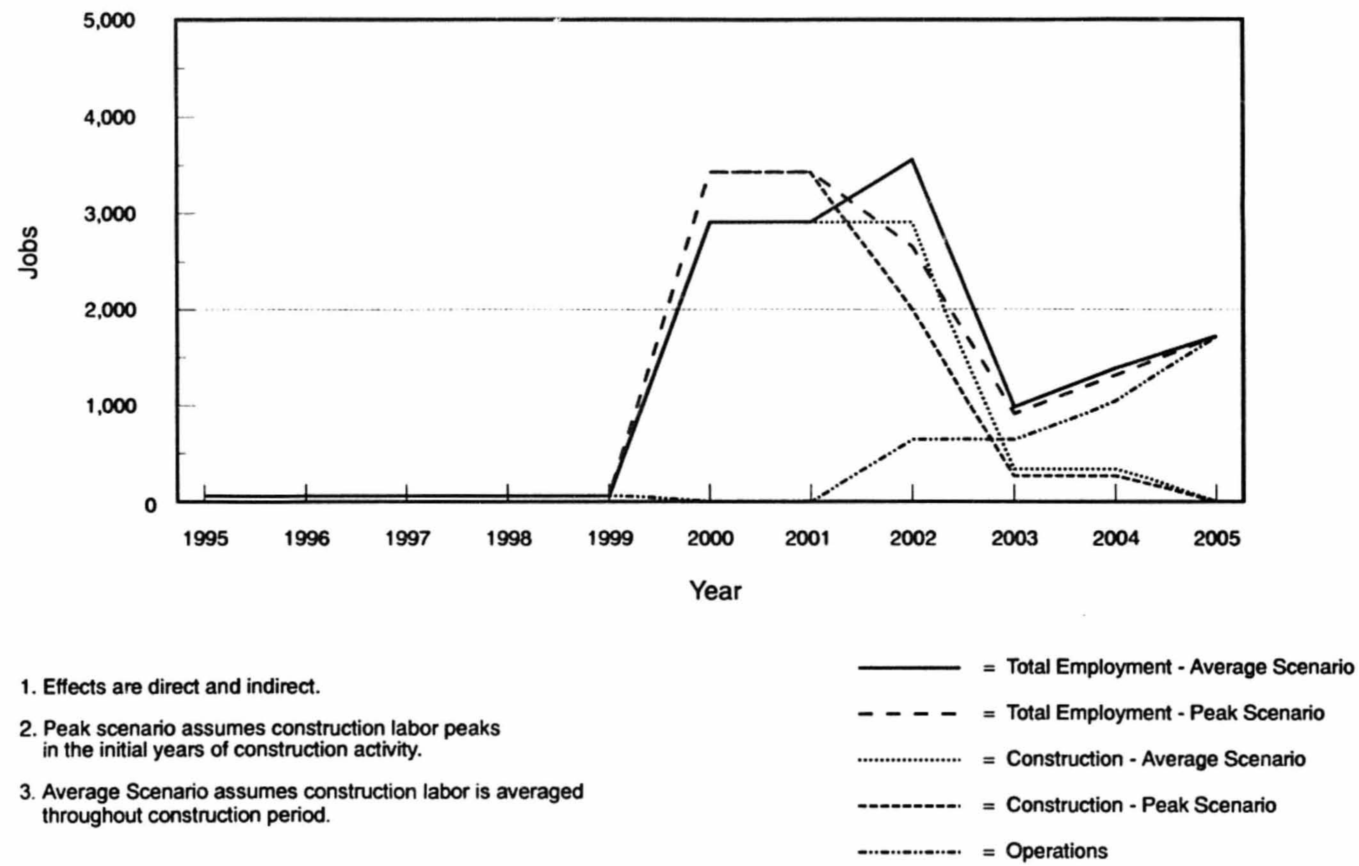

Figure 5.3-1. Total employment effects, NTS centralization alternative

Table 5.3-1. Socioeconomic effects - centralization of SNF at Nevada Test Site.

	Time period					
Years	1995 - 1999	2000, 2001	2002	2003	2004	2005 +
			Operations			
Direct jobs	25	0	300	300	487	800
Indirect jobs	29	0	344	344	559	918
Total jobs	54	0	644	644	1,046	1,718
			Construction			
Direct jobs						
Peak	0	1,587	928	125	125	0
Average	0	1,346	1,346	157	157	0
Indirect jobs						
Peak	0	1,839	1,076	145	145	0
Average	0	1,560	1,560	182	182	0
Total jobs						
Peak	0	3,426	2,004	270	270	0
Average	0	2,906	2,906	339	339	0
			Total			
Direct jobs						
Peak	25	1,587	1,228	425	612	800
Average	25	1,346	1,646	457	644	800
Indirect jobs						
Peak	29	1,839	1,420	489	704	918
Average	29	1,560	1,904	526	741	918
Total jobs						
Peak	54	3,426	2,648	914	1,316	1,718
Average	54	2,906	3,550	983	1,385	1,718
			Population Change			
Peak	91	5,664	(1,084)	(2,379)	547	540
Average	91	4,804	896	(3,522)	547	447

3-year period from years 2000 through 2002. Operation requirements would be minor until 2002, when engineering and administrative services are assumed to be in demand to accommodate project requirements. Ancillary SNF complex operations, such as utilities and research and development activities, are assumed to begin in 2004, taper off into 2005, and remain relatively constant through 2035. The maximum total SNF management direct jobs under either construction scenario would occur in 2002 with 1,346 construction jobs for the Average Scenario and 300 operation jobs. Implementation of the Centralization Alternative would increase the projected average annual rate of growth rate for both regional population and employment from 1995 through 2005 by 0.02 percent.

Regional businesses and the work force would benefit from increased competition for contract procurement and jobs. Most of this activity is anticipated to be captured by Clark County, with a smaller share occurring in Nye County. However, the impact to the regional economy represents only a portion of the total economic activity generated by the Centralization Alternative. For instance, purchases of specialized materials and technology acquisition may occur even outside the State of Nevada. It has been estimated that about 50 percent of total NTS expenditures occur within the State of Nevada (Nye County Board of Commissioners 1992). This leakage would result in the associated economic benefits accruing outside of the regional economy.

Most of the population change in the Region of Influence above the baseline forecast would be due to in-migration of labor and households to support SNF management activity at the NTS. It is likely that most of the SNF operation work force would be supplied by SNF personnel relocating from DOE sites where SNF inventories were stored before shipment to the NTS, since they are familiar with the processes, technologies, and research. Other demands for operational jobs not related to SNF management would be accommodated by the regional labor market. The regional labor market could accommodate most of the construction requirements, with the exception of very specialized tasks. Construction employment in Clark County is twice that of the national average. As the population continues to grow, demand on public infrastructure grows as well. These projects will result in continued growth in construction activity (Las Vegas Review Journal et al. 1993).

To assess potential population and housing impacts, an in-migration rate per job was estimated using a ratio between projected employment and population figures (Table 4.3-1). This ratio was applied to the number of total (direct and indirect) jobs created by SNF management activities at the NTS, resulting in the total estimated number of persons in-migrating into the Region of Influence per job created (Table 5.3-1).

With initial operation in 1995 under the both scenarios (Table 5.3-1) a total of 91 persons could migrate into the Region of Influence. The number of persons coming in would be at its largest for the years 2000 through 2001, (5,664 in-migrants for the Peak Scenario and 4,804 for the Average Scenario) the period when construction starts. In the final phases of construction, people would migrate out of the Region of Influence. However, the number of in-migrants would increase in the years 2004 and 2005, as more of the SNF management operations start. After 2005, in-migration due to SNF management activities would cease, since SNF management activities would not create any more jobs.

Construction of the SNF complex could result in a temporary increase in housing demand in Nye County. The demand for both the rental market and short-term lodging could increase. The demands on housing would fluctuate over time, based on the various construction phases, peak employment levels, the level of local sub-contracting, and any decision by a contractor to develop temporary housing arrangements near the job site. Within Nye County, the communities of Tonopah and Beatty would probably experience the most impacts related to housing demand. Both communities support fairly large inventories of temporary housing. While such demands are favorable for local lodging operators and landlords, they could compete with tourism demands (Nye County Board of Commissioners 1992).

Overall socioeconomic impacts to Clark County could be absorbed within the projected expansion of the county's economy, local infrastructure, public service, and real estate development.

5.3.2 Regionalization Alternative

Socioeconomic impacts resulting from the Regionalization Alternative are expected to be similar to those for the Centralization Alternative. The construction and operation cycles for each alternative would be the same; therefore, the same issues identified for the Centralization Alternative would apply. Labor requirements might be reduced slightly for the Regionalization Alternative. Although the volume of SNF stored would be less for the Regionalization Alternative, an economy of scale occurs for both alternatives, so that differences in labor and capital between the two alternatives would be minimized.

5.3.3 Mitigation Measures

5.3.3.1 Coordination with Local Jurisdictions. To reduce construction- and operation-related impacts, possible coordination with local communities could address potential impacts from increased labor and capital requirements. The knowledge of the extent and effect of growth due to SNF management activities could greatly enhance the ability of affected jurisdictions to plan effectively. Effective planning would address changes in levels of service for housing, infrastructure, utilities, transportation, and public services and finances.

5.3.3.2 Enhance Labor Force Availability. To alleviate potential impacts associated with the in-migration of labor, local labor force availability could be increased through various employment training and referral systems currently provided by the NTS. The goal of these systems would be to reduce the potential for in-migration of labor to support SNF management activities.

5.4 Cultural Resources

5.4.1 Centralization Alternative

Under the Centralization Alternative, the construction of SNF facilities is not expected to require the disturbance of more than 90 acres (0.36 square kilometer) on the NTS. There are no known historical, archeological, paleontological, or Native American traditional sites in the

proposed area or its vicinity. Therefore, no impacts to cultural resources are expected due to ground disturbance, noise, or air emissions during construction and operation of the SNF facilities. Consultation with the Nevada State Historic Preservation Office (SHPO) prior to project implementation is required under Section 106 of the National Historic Preservation Act of 1966. The SHPO may recommend that further archaeological studies be conducted throughout the construction area to verify that there are no archaeological sites subject to disturbance.

5.4.2 Regionalization Alternative

Under the Regionalization Alternative, the location of the SNF facilities would remain the same but could be reduced in area. As with the Centralization Alternative, impacts are not anticipated.

5.5 Aesthetics and Scenic Resources

5.5.1 Centralization Alternative

The proposed SNF facilities under the Centralization Alternative, when fully constructed and under operation, would consist of a series of industrial buildings set within a security fence on the proposed 90-acre (0.36 square-kilometer) site. The facility would have the appearance of industrial buildings ranging in height from one to three stories. The maximum height of the buildings contained within the site would not exceed 42 feet (13 meters) above ground level. The proposed SNF site is located within a valley over 10 miles (16 kilometers) from U.S. Route 95, separated by intervening hills and mountains, including Red Mountain, the Spotted Range, the Specter Range, Hampel Hill and Skull Mountain. The site would not be visible from areas outside the NTS or the Nellis Air Force Base Bombing and Gunnery Range. Therefore, impacts to aesthetics and scenic resources are not anticipated.

5.5.2 Regionalization Alternative

Under the Regionalization Alternative, proposed SNF facilities could be reduced in area and intensity of operations from the Centralization Alternative. Environmental effects to aesthetics and scenic resources could also be less than that of the Centralization Alternative.

5.6 Geologic Resources

This section describes any incremental or additional impacts on geology and geologic resources that would result from the construction and operation of the new facilities associated with the storage of SNF at the NTS. Seismic and volcanic hazards are discussed in Section 4.6.

5.6.1 Centralization Alternative

As discussed in Section 4.6.2, precious metal deposits may exist in certain carbonate rocks and volcanic or sedimentary rocks at the NTS. Figure 4.6-5 shows the proposed SNF site in relation to these types of geologic terranes as well as to the locations of mining districts. Although the proposed SNF facilities would not be located within a mining district, they would be situated on Tertiary volcanic or sedimentary rocks near volcanic or intrusive centers (the type of geologic terrane where small to medium-size precious metal deposits could be developed). However, because the NTS would likely remain closed to mining operations, the impact on any precious metal deposits that might exist at the NTS would not change if the proposed storage facility were to be sited there.

In addition, destruction of unique geologic features are not expected to occur as a result of construction and operation of a new SNF storage facility nor are mass movement and subsidence and sediment runoff from land disturbances.

5.6.2 Regionalization Alternative

Impacts to geology and geological resources under the Regionalization Alternative would generally be as described for the Centralization Alternative.

5.7 Air Resources

Both radiological and nonradiological air emissions impacts from the proposed SNF facilities are discussed in this section.

5.7.1 Centralization Alternative

5.7.1.1 Emissions.

5.7.1.1.1 Radiological Emissions—There would be no radiological emissions from construction of the proposed SNF facilities. The total annual airborne radionuclide releases from operation of the proposed SNF facilities are provided in Table 5.7-1.

5.7.1.1.2 Nonradiological Emissions—During construction of the proposed SNF facilities, short-term emissions, such as fugitive dust and heavy equipment exhaust emissions, would be temporary and only affect receptors close to construction areas. Fugitive dust emissions would be minimized by curtailing soil-disturbing activities during high winds. During operation of the proposed SNF facilities, criteria and hazardous air pollutants would be emitted. The total annual emissions from all modules associated with the proposed SNF facilities are listed in Table 5.7-2.

5.7.1.2 Air Quality.

5.7.1.2.1 Radiological—The GENII environmental transport and dose assessment model (PNL 1988) was used with 1990 meteorological data from Desert Rock Army Airfield to determine effective dose equivalents from the radiological emissions listed in Table 5.7-1. A population of 15,100 persons was estimated to be within 50 miles (80 kilometers) of the proposed SNF facilities. It was also assumed that 1995 operations at the NTS would result in the same baseline radiological emissions as the 1992 operations at the NTS. The most recent comprehensive radiological emissions report at the NTS was based on 1992 operations.

Table 5.7-1. Annual airborne radionuclide emission source terms for proposed NTS SNF facility operational phase.[a]

Isotope	Release rate (Ci/yr)[b,c]
Tritium	7.9×10^{-1}
Carbon-14	1.2×10^{0}
Manganese-54	2.2×10^{-8}
Cobalt-60	4.2×10^{-8}
Krypton-85	1.0×10^{4}
Strontium-90	3.3×10^{-6}
Yttrium-90	2.0×10^{-6}
Ruthenium-106	1.1×10^{-5}
Antimony-125	3.4×10^{-4}
Iodine-129	1.0×10^{-1}
Cesium-134	6.2×10^{-8}
Cesium-137	4.8×10^{-5}

a. Source: Johnson (1994).

b. 2.0×10^{-6} Ci/yr of Barium-137m, from Wet Storage, is not in GENII. Barium-137m, with a half-life of 2.55 min, decays to Barium-137, which is stable.

c. 7.5×10^{-8} Ci/yr of Thallium-208, from Wet Storage, is not in GENII. Thallium-208, with a half-life of 3.10 min, decays to Lead-208, which is stable.

Table 5.7-2. Total annual nonradioactive emissions for the SNF storage facility at NTS.[a]

Criteria pollutants	Release rate (kg/yr)
Carbon monoxide	1.7×10^{3}
Particulate matter (PM_{10})[b]	1.0×10^{-3}
Nitrogen oxides	5.5×10^{3}
Sulfur dioxide	1.3×10^{2}
Lead	5.0×10^{-9}

Hazardous air pollutants	Release rate (kg/yr)
Selenium compounds	1.6×10^{-4}
Mercury compounds	5.1×10^{-1}
Chlorine	3.5×10^{3}
Hydrogen fluoride	1.6×10^{1}
Cadmium compounds	2.9×10^{-7}
Cobalt, chrome, antimony, and nickel compounds	2.0×10^{-10}

a. Source: Johnson (1994).

b. All suspended particulate matter is assumed to be PM_{10}.

Table 5.7-3 summarizes the sum of the baseline and the incremental contribution from the proposed SNF facilities to the effective dose equivalents of the maximum site boundary individual and, collectively, to the population within 50 miles (80 kilometers) of the proposed facility. These combined effective dose equivalents for operation of the proposed SNF facilities would be less than 1 percent of the National Emissions Standards for Hazardous Air Pollutants (NESHAP) standard and less than 1 percent of the natural background radiation.

5.7.1.2.2 Nonradiological—The Industrial Source Complex Short Term air dispersion model (EPA 1992) was used with 1990 meteorological data from Desert Rock Army Airfield to determine pollutant concentrations resulting from the Centralization Alternative nonradiological emissions listed in Table 5.7-2. A maximum emissions baseline was established to characterize conditions that could result if all sources operated to the maximum extent allowed by permit conditions. It was also assumed that 1995 operations at the NTS would result in the same baseline nonradiological emissions as the 1990 operations at the NTS. The most recent comprehensive nonradiological emissions report at the NTS was based on 1990 operations. The results of modeling are in Table 5.7-4, where a comparison of the existing DOE site contribution concentration is compared to the existing DOE site contribution concentration plus the proposed SNF contribution. The increases in pollutant concentrations from operation of the proposed SNF facilities would be negligible in magnitude. The concentrations of pollutants at the NTS with the inclusion of the proposed SNF facilities would remain within regulatory guidelines.

The calculated atmospheric maximum concentrations at the site boundary and offsite for the proposed SNF facilities are presented in Table 5.7-5. The maximum concentrations at the site boundary reflect exposure to a maximally exposed individual, whereas the maximum onsite concentrations reflect exposure to a worker.

5.7.2 Regionalization Alternative

As with the Centralization Alternative, construction of the proposed SNF facilities under the Regionalization Alternative would not result in radiological air emissions, but could result in minor, temporary emissions of fugitive dust. These emissions could be slightly less than under the Centralization Alternative, since the extent of construction disturbance would be less.

Table 5.7-3. Summary of effective dose equivalents to the public from proposed SNF storage facility plus 1995 baseline operations at NTS.[a]

	Maximally exposed individual dose[b]	Collective dose to population within 80 km of NTS sources
Dose	1.3×10^{-1} mrem per year[c]	8.7×10^{-2} person-rem[d]
NESHAP standard	10 mrem per year	--
Percentage of NESHAP standard	1.3	--
Natural background dose	278 mrem per year	4190 person-rem per year
Percentage of natural background dose	4.7×10^{-2}	2.1×10^{-3}

a. Effective dose equivalents computed using GENII (PNL 1988).

b. The maximum boundary dose is to the hypothetical individual who remains in the open continuously during the year at the NTS boundary.

c. The SNF facility contributes 1.2×10^{-1} millirem to this dose.

d. The SNF facility contributes 8.2×10^{-2} person-rem to this dose.

Table 5.7-4. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at NTS for proposed SNF facility plus current operations.

Criteria pollutant	Averaging time	Most stringent regulation or guideline[d] ($\mu g/m^3$)	Maximum background concentration ($\mu g/m^3$)	Total existing maximum concentration[e] ($\mu g/m^3$)	Total projected maximum concentration[f] ($\mu g/m^3$)	Increase in maximum concentration ($\mu g/m^3$)
Carbon dioxide	8-hour	10,000	2,290	2,290	2290.8	0.80
	1-hour	40,000	2,748	2,748[b]	2754.0	6.03
Nitrogen dioxide	Annual	100	a	b	0.20	0.20
Lead	Calendar quarter	1.5	a	b	3.7×10^{-12}	3.7×10^{-12}
Particulate matter (PM_{10})[c]	Annual	50	a	0.43	0.43	0
	24-hour	150	78.3	84.9	84.9	0
Sulfur dioxide	Annual	80	a	1.1	1.1	0
	24-hour	365	39.3	55.2	55.2	0
	3-hour	1,300	65.4	170.3	170.3	0
Hazardous air pollutants						
Selenium	8-hour	4.8	a	b	2.18×10^{-7}	2.18×10^{-7}
Mercury compounds	8-hour	0.2	a	b	2.18×10^{-3}	2.18×10^{-3}
Chlorine compounds	8-hour	71.4	a	b	1.52	1.52
Hydrogen fluoride	8-hour	59.5	a	b	3.70×10^{-3}	3.70×10^{-3}
Cadmium compounds	8-hour	1.2	a	b	1.81×10^{-9}	1.81×10^{-9}
Cobalt, chromium, antimony, and nickel compounds[g]	8-hour	1.2	a	b	5.5×10^{-10}	5.5×10^{-10}

a. Not measured.

b. No sources indicated.

c. All suspended particulate matter is assumed to be PM_{10}.

d. Criteria pollutant regulations are National Ambient Air Quality Standards. Hazardous air pollutant regulations are Nevada Ambient Air Quality Standards.

e. Includes background concentration plus existing DOE facilities impact concentration. This is the baseline concentration.

f. Includes background concentration plus existing DOE facilities impact concentration plus SNF facilities impact concentration.

g. Individual emission rates were not specified for each of cobalt, chrome, antimony, and nickel compounds. Only a total emission rate for all four was provided. Therefore, the most stringent standard for any of the four compounds, 1.2 $\mu g/m^3$ for cobalt, was used.

Table 5.7-5. Calculated annual maximum concentrations for hazardous air pollutants at NTS, onsite and offsite.[a]

Hazardous air pollutant	Maximum annual average concentration onsite ($\mu g/m^3$)	Maximum annual average concentration offsite
Selenium compounds	6.03×10^{-8}	1.20×10^{-8}
Mercury compounds	6.03×10^{-4}	1.20×10^{-4}
Chlorine compounds	4.2×10^{-1}	8×10^{-2}
Hydrogen fluoride	1.02×10^{-3}	2.04×10^{-4}
Cadmium compounds	5.01×10^{-10}	1.0×10^{-10}
Cobalt, chromium, antimony and nickel compounds	1.50×10^{-10}	3.00×10^{-11}
Lead	1.21×10^{-11}	2.40×10^{-12}

a. All impacts from proposed source only. No hazardous air pollutant emissions information available for existing sources.

The same types of radiological and nonradiological air emissions from operation of the proposed SNF facilities would occur under the Regionalization Alternative as under the Centralization Alternative. However, the magnitudes could be lower. As with the Centralization Alternative, the combined dose equivalents from the operation of the proposed SNF facilities would be less than 1 percent of the NESHAP and less than 1 percent of the natural background radiation. The concentrations of non-radiological air emissions from the operation of the proposed SNF facilities under this alternative would remain within all applicable regulatory guidelines (EPA 1992; PNL 1988).

5.8 Water Resources

Construction and operation of the SNF modules could affect surface and groundwater resources. Potential environmental impacts to surface water and groundwater resources during construction include depletion of groundwater supplies, floodplain encroachment, and surface water sedimentation from erosion runoff occurring after land clearing. Potential normal operational impacts could include depletion of groundwater supplies and diminished surface water and/or groundwater quality resulting from wastewater discharges from normal operations.

5.8.1 Centralization Alternative

Separate discussions are provided for surface water quantity, surface water quality, groundwater quantity and groundwater quality.

5.8.1.1 Surface Water Quantity. Existing activities on the NTS derive their water supply from groundwater sources, and the same would be true for construction and operation of the proposed SNF facilities. Therefore, construction and operation of the proposed SNF facilities would have no impact on surface water availability in the region. In addition, under normal operating conditions, there would be no wastewater discharges to Area 5 watercourses which could affect surface water flow characteristics.

Stormwater runoff associated with construction and operation of the proposed SNF facilities is expected to have a negligible impact on surface water quantity. During construction, standard

stormwater management techniques would be employed to attenuate runoff. The impact of stormwater runoff on the ephemeral character of Area 5 watercourses during operation of the SNF facilities is also expected to be negligible. A site drainage and stormwater management system consisting of a perimeter drainage ditches and a retention pond would be included as part of the SNF facilities (Johnson 1994). This system would provide for control of runoff and erosion, which otherwise could affect Area 5 watercourses or the SNF facilities.

As discussed in Section 4.8.1, analyses of available data indicate that the areas encompassed by the proposed SNF facility may lie in flood Zone X (100-year flood zone with depths less than 1 foot [0.30 meter]) and/or Zone AO (100-year flood zone with depths between 1 and 3 feet [0.30 and 0.9 meter]) associated with the Halfpint Alluvial Fan. Accordingly, the SNF facilities would have to be located and constructed to minimize floodplain impacts and to avoid floodplains to the maximum extent possible, as required by Executive Order 11988 (Floodplain Management) and DOE Orders. Site-specific surveys would be performed to determine locations of flooding elevations more accurately.

5.8.1.2 Surface Water Quality. The proposed SNF facility in the northeast portion of Area 5 is not served by the NTS sanitary sewer system. A number of NTS facilities have self-contained sanitary sewer systems. The nearby Radioactive Waste Management Site does have its own septic tank and leach field system to dispose of sanitary wastewater (DOE/NV 1993a). The proposed SNF facilities would have a sanitary sewer system comprised of a sewage treatment facility equipped with a sewage treatment and ejection pump system with a programmable controller and software. A pressurized sanitary sewer line would be provided to run to a sewage lagoon at the facility (Johnson 1994). This system would be adequate to accommodate the estimated 9,863 gallons (37,335 liters) per day of sanitary wastewater generated by the SNF facilities and personnel. This system would be operated in accordance with State of Nevada permitting requirements.

The proposed SNF facilities are designed to generate no liquid releases of wastewater with hazardous chemicals or radiological characteristics related to SNF management operations. These facilities would be constructed using state-of-the art technologies including secondary containment, and leak detection and water balance monitoring equipment. The normal operation of the proposed SNF facilities is not expected to affect the quality of any surface water on or near the NTS.

During construction, 90 acres (0.36 square kilometer) would be disturbed, all of it in previously undisturbed areas. This would create the potential for increased sediment runoff into dry washes and shallow drainages or to spread out overland as a result of sheetflow. However, sediment runoff from construction activities would be controlled by implementing soil erosion control measures, which would result in negligible effects to surface water quality.

In addition, as stated in Section 4.8.1, existing onsite contaminants may be transported and dispersed beyond the facility boundary during flooding (USAF et al. 1991). Therefore, the potential exists for some incremental transportation and dispersion of any additional contaminants that might result from the construction or operation of the SNF facilities. Although this potential cannot be determined without additional studies, any additional contamination would be unlikely, due to the design of the containment structures and leak detection system of the SNF facilities.

5.8.1.3 Groundwater Quantity. Operation of the SNF facilities would require approximately 9,863 gallons (37,335 liters) per day. This translates to an additional 3,600,000 gallons (13,627 cubic meters) of water used at the NTS per year. It is assumed that the water demand of the SNF facilities would be supplied via the existing NTS Area 5 supply wells and water distribution system. If this scenario should be demonstrated to be infeasible or impractical, a water supply and distribution system consisting of two 8-inch-diameter wells supplying two 250,000-gallon (946,333-liter) aboveground storage tanks would be constructed to service the SNF facility complex (Johnson 1994).

Water withdrawals to support the proposed SNF facilities would likely be from the Frenchman Flat hydrographic area of the Ash Meadows Subbasin. In 1993, 176 million gallons (666,000 cubic meters) of groundwater was withdrawn by DOE from the Frenchman Flat hydrographic area. An additional 3.6 million gallons (14,000) cubic meters) per year would be required for SNF operations. The recharge due to precipitation in the Frenchman Flat hydrographic area was estimated to be 32.6 million gallons (123,000 cubic meters) (Rush 1970).

This recharge estimate was exceeded for more than thirty years with no decline in static water levels (DOE 1988b). Accurate measurement of static water levels are, however, precluded by numerous conditions on the NTS (Winograd 1970). More detailed analyses of perennial yield and total water withdrawal from the hydrographic area would be required if the NTS were chosen as a site for SNF management facilities, but because the estimated perennial yield has been exceeded for more than thirty years with no measurable decline in static water levels, it is likely that increased water use for the SNF Management Facility could be sustained.

Because of hydrogeologic complexities, a regional groundwater flow at the NTS is not constrained by the hydrographic basins which are defined by local topography (USAF et al. 1991). Therefore any potential groundwater overdrafts in the Frenchman Flat hydrographic area indicated by previous yield estimates are likely made up by untapped groundwater from neighboring hydrographic areas. Localized impacts could occur if the perennial yield of Frenchman Flat hydrographic area is exceeded. Potential impacts include depletion of water stored locally in the regional aquifer, removal of that groundwater from other potential uses, and the potential modification of the rate and direction of contaminant migration resulting from underground nuclear testing. The complex issues of groundwater contamination and use are being addressed in the Resource Management Plan being prepared in conjunction with the NTS site-wide EIS.

The vast majority of groundwater not withdrawn from the Frenchman Flat hydrographic area, and the Ash Meadows Subbasin as a whole, is discharged at Ash Meadows. Using 1993 water withdrawal data, NTS annual withdrawal from the Ash Meadows Subbasin would only increase by 1% or 3.6 million gallons (14,000 cubic meters) to approximately 370 million gallons (1.4 million cubic meters) if the proposed SNF facilities were sited on NTS. This increase in withdrawal would have little impact on the subbasin as a whole as its perennial yield is estimated to be 12 to 18 billion gallons (46 to 68 million cubic meters) (DOE 1988b; USAF et al. 1991). Water from the groundwater systems which pass beneath the NTS annually discharge approximately 8.8 billion gallons (33 million cubic meters) to the deserts southwest of the NTS (DOE/NV 1993b). Annual groundwater withdrawal for SNF operations would amount to 0.04 percent of this discharge. No impacts to down-gradient users and discharge areas would be expected due to the small volume of water required and the vast amount of water in the regional groundwater system.

Dewatering is not expected to be necessary to construct the SNF facility complex, due to the relatively great depth to groundwater across the NTS. Although perched water table conditions at depths of 70 feet (21 meters) have been reported for Frenchman Flat, all excavation activities are expected to occur in the vadose zone. Consequently, there would be no effect on groundwater quantity due to construction dewatering of wastewater with hazardous chemical or radiological characteristics related to SNF management activities.

5.8.1.4 Groundwater Quality. As previously mentioned, the proposed SNF facilities are designed to have no liquid release to the environment. However, for the purpose of this water resource analysis, a conservative release scenario was evaluated to identify the potential environmental consequences of a liquid release to the environment under normal operating conditions. The release scenario was evaluated for information purposes only, as no normal operating releases are planned for the proposed facility. The scenario consisted of a maximum potential liquid release to the environment under normal operating conditions such as an undetected secondary containment failure or piping leak. The scenario was evaluated using conservative estimates of the sensitivity of actual leak detection systems and operational source term data from similarly functioning facilities at the Idaho National Engineering Laboratory (INEL). The conservative estimates for the hypothetical release included a point release of 5 gallons (19 liters) per day to the environment over the course of 1 month. The release volume and durations were considerably greater than existing leak detection system sensitivities, surveillance activities, and radiological surveys. Source terms were derived at the 95 percent confidence level from 8 years of operational data at the INEL Fluorinel and Storage Facility at the Idaho Chemical Processing Plant.

The point source release as described above has been conservatively assumed to occur at a depth of 40 feet (12 meters) below land surface (the bottom of the Wet Storage Basin for the Receiving/Canning Facility). As detailed in Section 4.8.2, this is well within the vadose zone underlying Area 5 at Frenchman Flat. Vertical flow in the uppermost portions of the vadose zone at Area 5 is generally upward toward the surface, due to an extremely high

evapotranspiration rate relative to precipitation. Site characterization data for Area 5 indicate that the vertical flow direction in the vadose zone is upward from 0 to 75 meters (0 to 250 feet) below land surface. In the next interval (75 to 180 meters [250 to 600 feet]), a downward flow rate of 3 meters/1,000 years (10 feet/1,000 years) has been calculated. At a depth of 180 to 250 meters (600 to 800 feet), a zone of equilibrium is present above the water table (a zone of no vertical movement). These data, combined with the relatively extensive depth to the water table (244 meters [800 feet]) and extreme travel times to the water table, indicate that the release described above would be highly unlikely to reach the saturated zone. The release would likely remain indefinitely in the vadose zone beneath the proposed SNF facilities, where it would present a persistent source of contamination but would not affect groundwater quality.

5.8.2 Regionalization Alternative

Potential impacts to surface water and groundwater from construction and operation of the proposed SNF facilities under the Regionalization Alternative would generally be as described for the Centralization Alternative. However, the quantity of groundwater withdrawn to support operation of the proposed facilities could be less.

5.9 Ecological Resources

The Centralization and Regionalization Alternatives could potentially affect ecological resources primarily through the alteration or loss of habitat. Potential impacts to terrestrial and aquatic resources and threatened and endangered species are described below for both alternatives.

Radiation doses received by terrestrial biota from waste management activities would be expected to be similar to those received by humans. Although guidelines have not been established for acceptance limits for radiation exposure to species other than humans, it is generally agreed that the limits established for humans are also conservative for other species (NRC 1979). Evidence indicates that no other living organisms have been identified that are likely to be substantially more radiosensitive than humans (Casarett 1968; National Academy of Sciences 1972). Additionally, work areas where potential radiation exposure is high and monitored site workers utilize protective equipment, have controlled access measures which limit entry by biota. Thus, so long as exposure limits protective of humans are not exceeded, no substantial radiological impact on populations of biota would be expected as a result of waste management activities at the proposed SNF facility.

5.9.1 Centralization Alternative

Under this alternative, 90 acres (0.36 square kilometer) of the creosote bush plant community would be disturbed during construction. The area disturbed would include construction laydown areas, grading, and new buildings. In addition, disturbance would be expected along access roads and other rights of way which have not been included in the 90 acres. This plant community is common to the southern portion of NTS. To obviate any impacts to this plant community, ground-disturbing activities would be kept to a minimum. This would also serve to reduce the number of non-native species, such as Russian thistle, to the area. However, non-native species would probably become established in some areas, for example, along the access road.

Impacts to wildlife would occur as a direct result of habitat loss and/or an indirect result of increased human presence. There could be a decrease in the number of small mammals and reptiles during the construction period due to ground-disturbing activities. More mobile animal species would be able to move to other areas on the NTS during construction. Depending upon the carrying capacity of these areas, there could be increased competition for food and water resources. After construction activities are complete, it is expected that species which adapt to developed areas would become established.

Impacts to birds protected under the Migratory Bird Treaty Act are expected to be minimal during construction, since there are no water sources at the proposed site. However, surveys prior to construction may be required by the U.S. Fish and Wildlife Service. During operation, there may be an increase in migratory birds utilizing the area due to the increase in water sources.

There would be no impact on wetlands or aquatic habitats due to the construction of the facility because these habitats do not exist in the area. The operation of the proposed SNF facilities would increase water sources for wildlife species due to retention ponds and a sewage lagoon area. This could bring an increase in species, especially migratory birds, seeking aquatic habitats. The addition of new species to the area would impact upon the general ecology by increasing diversity of species. Since these areas would be within fenced enclosures, it is expected that the larger mammals would be unable to directly utilize these water sources.

Noise and activity associated with construction would be expected to have short-term effects on most wildlife. Studies on the effects of noise on wildlife have shown varying responses by different species. Responses include becoming frightened and running away, altering migration or breeding patterns, changing home ranges (often decreasing them), or adapting to the noise and activity (EPA 1980). These effects would continue indefinitely during the operating life of the proposed SNF facilities.

Potential impacts to threatened and endangered species would be the direct result of increased human presence and the loss or alteration of habitat. Any Federal Candidate or state-protected species on the site would result in further consultation with the U.S. Fish and Wildlife Service and the Nevada State Forester. Mitigation plans would be developed in cooperation with the appropriate agencies if any of these species were identified on the project site.

Although positive identification of most of the species listed on Table 4.9-1 has not occurred during prior studies, the addition of water sources to the area could increase the suitability of habitat for some endangered, threatened, or candidate bird species. These might include birds of prey (bald eagle, peregrine falcon, ferruginous hawk, and golden eagle), and species which inhabit water areas such as shorebirds (mountain plover, western least bittern, western snowy plover, and white faced ibis). An increase in loggerhead shrikes may occur due to the fencing that would be erected around the facility and would serve as posts for this bird.

The project area is located within the range of the desert tortoise, a federally listed threatened species. Recent pre-activity surveys for other nearby projects have not identified the desert tortoise in the general area of the project site. However, a pre-activity survey for this project would be needed to determine the presence or absence of the desert tortoise and other species of concern. If present, the desert tortoise could be impacted during construction of the proposed SNF facilities due to increased vehicular traffic, construction of trenches for utilities, and other temporary construction excavations. Prior to and during construction activities, fencing of the areas and removal of tortoises within the fence would decrease the potential to bring harm to the desert tortoise. All activities with this species must be completed by a qualified biologist.

5.9.2 Regionalization Alternative

Impacts under this alternative are expected to be generally the same as under the Centralization Alternative. The major difference between the two is the total area to be disturbed. The Regionalization Alternative is expected to involve construction of fewer buildings and, therefore, to require disturbance of less land.

5.10 Noise

As discussed in Section 4.10, noises generated on the NTS do not propagate offsite at levels that impact the general population. Thus, the NTS noise impacts for both the Centralization and Regionalization Alternatives would be limited to those resulting from the transportation of personnel and materials to and from the site, which affect the nearby communities, and those resulting from onsite sources which may affect some wildlife near these sources. The effect of noise on wildlife near SNF management facilities under the Centralization or Regionalization Alternatives would be addressed in a project-specific environmental assessment.

The transportation noises are a function of the size of the work force (e.g., an increased work force would result in increased employee traffic and corresponding increases in deliveries by truck and rail, and a decreased work force would result in decreased employee traffic and corresponding decreases in deliveries). The analysis of traffic noise took into account noise from the major roadway which provides access to the NTS. Vehicles used to transport employees and personnel on roadways would be the principal sources of community noise impacts near the NTS from the Centralization and Regionalization Alternatives.

This analysis used the day-night average sound level to assess community noise, as suggested by the U.S. Environmental Protection Agency (EPA 1982, 1974) and the Federal Interagency Committee on Noise (FICON 1992). The change in the day-night average sound level from the baseline noise level for each alternative was estimated based on the projected change in employment and traffic levels from the baseline levels. The baseline is comparable to current activity at the NTS for 1993. The combination of construction and operation employment was considered. The traffic noise analysis considered U.S. Route 95, which employees use to access the NTS from Las Vegas. Changes in noise level below 3 decibels would not be expected to result in a change in community reaction (FICON 1992).

5.10.1 Centralization Alternative

Under the Centralization Alternative, the projected NTS work force would increase by about 48 percent of existing onsite employment in the years 2000 to 2002, the peak construction period, and decrease thereafter (Section 5.3). There would be a corresponding increase in truck, private vehicle, and bus trips. The day-night average sound level at 50 feet (15 meters) from U.S. Route 95 would be expected to increase by about 1 decibel. No change is expected in the community reaction to noise along this route. No mitigation efforts are necessary.

5.10.2 Regionalization Alternative

Under the Regionalization Alternative, traffic noise impacts would be the same as for the Centralization Alternative.

5.11 Traffic and Transportation

The proposed SNF management activities would involve a small increase in the number of employees commuting to the NTS and the transportation of SNF and hazardous chemicals on the NTS. This section summarizes potential transportation impacts due to the proposed SNF facilities on the NTS.

5.11.1 Centralization Alternative

5.11.1.1 Levels of Service. Levels of service were calculated for construction and operation of the SNF facility at the NTS. The maximum reasonably foreseeable scenario for construction and operations occurs when the combined number of employees and population are at their highest. This would occur in 2001, when there would be 3,426 employees and a projected baseline population in the Region of Influence of 1,209,316. The Region of Influence includes Nye and Clark counties. Direct employees associated with the proposed SNF facility generate direct trips in the Region of Influence. These trips are distributed to the Region of Influence road network according to percentages based on a traffic flow between the site and where employees historically have lived. Increases in baseline population and indirect site-related employees generate indirect trips in the Region of Influence. These trips are distributed based on the current average daily traffic per present population in the region of influence for a given segment. Direct and indirect average daily traffic are added and a new level of service is determined. Construction and operation employees contribute little to the future traffic because they represent such a small percentage of the Region of Influence population growth.

None of the future baseline levels of service would change due to SNF-related impacts.

5.11.1.2 Rail Transportation. The generic facility design would require rail access for Naval fuel delivery. The rail spur would most likely be built from the Union Pacific line, located approximately 50 miles (80 kilometers) east of the NTS. Impacts from construction and operation of the rail spur would be evaluated in detail if the site were selected for the SNF facility.

5.11.1.3 Transportation Impacts of Hazardous Chemicals. It is assumed that the hazardous chemicals required and hazardous waste generated by the proposed SNF facility operation would be transported by truck. The onsite transportation impacts for these hazardous chemicals and wastes shipments are calculated based on the assumptions that they do not have any incident free impacts, the material would not leak during transport, only risk is due to traffic fatalities, and the material spill of entire contents is bound by the risk evaluated for the Expended Core Facility, considered under facility accidents.

The total distance for onsite shipment of these hazardous chemicals is assumed to be the maximum site boundary distance from the proposed SNF facility to the nearest highway. Based on the unit risk factor (Cashwell et. al. 1986), occupational and non-occupational fatalities considering a rural setting the onsite transportation risks are calculated, assuming 10 annual shipments.

The maximum one-way distance from the site to the NTS gate by which trucks would deliver hazardous wastes is 20 miles (32 kilometers). Based on 1.5×10^{-8} accident occupational fatalities per kilometer per shipment, 4.0×10^{-4} accident occupational fatalities are estimated over a 40-year period. Based on 5.3×10^{-8} accident non-occupational fatalities per kilometer per shipment 1.4×10^{-3} accident non-occupational fatalities are estimated over a 40-year period.

5.11.1.4 Transportation Impacts of Radioactive SNF. The definition of offsite transportation include transportation of radioactive material from the shipping facility to the storage facility at the receiving site; therefore, local transportation does not separately address the onsite transportation impacts due to radioactive material shipment.

5.11.2 Regionalization Alternative

The impacts due to the Regionalization Alternative would be less than those described for the Centralization Alternative due to the smaller size of the facility and the smaller amount of waste expected.

5.12 Occupational and Public Health and Safety

The Waste Minimization and Pollution Prevention Awareness Plan at the NTS would be implemented within the SNF Management Program. While more chemicals per year would be used, health impacts to the public would continue to be minimal as a result of administrative and design controls to minimize releases of radioactive and chemical pollutants to the environment and to achieve compliance with permit requirements and applicable standards. Workers would continue to be protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, management controls, and occupational standards that would limit atmospheric and drinking water concentrations of potentially hazardous chemicals as well as limit radiation exposures. This would include protection from wastes generated from the increased use of the chemicals needed to accommodate spent fuel storage and from radioactivity associated with this storage. The NTS Emergency Preparedness Plan would continue to operate as designed to minimize or mitigate the impact of any emergency upon the health and safety of employees and the public.

Health effects from radiation are presented here as the risk of fatal cancer. This risk is in the ratio of their health risk estimator (risk of fatal cancer per rem of exposure). The value of this estimator for exposures to the public is 5.0×10^{-4} for fatal cancers. The corresponding estimator for exposures to workers is 4.0×10^{-4}.

5.12.1 Centralization Alternative

This section evaluates the impacts to human health resulting from both contaminated air emissions and direct exposures associated with the proposed SNF facility under the Centralization Alternative. Pathways assessed include inhalation of air, ingestion of food, submersion in plumes, and direct exposure.

5.12.1.1 Radiological Doses. Releases of additional radionuclides to the environment from operations at the proposed SNF facilities are summarized in Table 5.7-1. The annual committed doses to the public resulting from the proposed SNF facilities plus baseline operations in 1995 are provided in Table 5.7-3. The doses would be approximately 1 percent of the most restrictive health standard, and less than 0.1 percent of the natural background radiation. The dose to the maximally exposed member of the public is assumed to remain constant over the 40-year operational lifetime of the SNF; the population dose would increase slightly (less than 3 percent) due to population growth during this 40-year period.

Doses to SNF facility workers are assumed to be similar to those presently received by major DOE facility Waste Processing/Management personnel. Based on data for the years 1989 through 1991 for the Hanford Site, INEL and the Savannah River Site (SRS) (DOE 1992), it is estimated that the average dose to a worker from annual SNF operations at the NTS would be

approximately 40 millirem and the maximum dose would be about 3,000 millirem. Assuming that 800 persons were involved at the peak of these operations, the total worker dose from annual SNF operations would be approximately 32 person-rem. Adding the baseline contribution, the total dose to all workers at the NTS would be about 36 person-rem.

5.12.1.2 Nonradiological Doses. Releases of additional nonradiological airborne pollutants from operations at the proposed SNF facilities are summarized in Table 5.7-2. The concentrations from these releases have been calculated and are presented in Tables 5.7-4 and 5.7-5.

5.12.1.3 Radiological Health Effects. The fatal cancer risk to the most exposed member of the public due to operation of the proposed SNF facilities would be 5.9×10^{-8}. The fatal cancer risk to the most exposed member of the public due to operation of the proposed SNF facilities plus baseline operations (1995 levels) would be 6.5 x 10, over 40 years (estimated storage duration), the risk to this individual would be approximately 2.6×10^{-6}. The estimated number of fatal cancers to the population within 80 kilometers (50 miles) of the proposed facility would be 4.4×10^{-5} for the operation of SNF facilities plus baseline operations and 4.1×10^{-5} for the operation of the SNF facilities without baseline operations. The number of increased fatal cancers from total NTS operations to the public during the estimate storage duration of the SNF would be approximately 1.8×10^{-3}. The number of fatal cancers from all causes that would normally be expected to occur during this same time period to the 80-kilometer population is 1,500.

The calculation of the number of health effects to SNF workers from annual operations is based on somewhat lower risk estimators than for the general public. The estimators are lower as the result of different age distributions among workers and members of the public. The risks of fatal cancer to the average worker is estimated to be 1.6×10^{-5}. The corresponding risk to the maximally exposed worker is estimated to be 1.2×10^{-3}. An excess of 0.013 fatal cancer among all SNF facility workers is projected from peak annual operations. It is projected that exposures to radiation over the lifetime of SNF operations could result in an excess of 0.40 fatal cancer among these workers and an increased risk of 6.4×10^{-4} to an individual worker who is present over this time period. The risks and numbers of excess fatal cancers, both from annual and lifetime operations, would be increased by about 15 percent if the impacts to workers associated with baseline activities (Section 4.12.2.1) were included. The health effects due to radiological doses to a noninvolved worker, i.e., an NTS worker involved in activities other than SNF, would be on the order of 1 percent of the occupational exposure to an SNF worker, based on analyses for the SRS and INEL sites.

5.12.1.4 Nonradiological Health Effects. As indicated in Table 5.7-4, the concentrations of all measured nonradiological pollutants at the NTS together with the inclusion of the Proposed Action would remain well within the health-based regulatory guidelines. The increases in pollutant concentrations from the Proposed Action would be negligible, compared to the existing baseline concentration; no adverse health effects from these pollutants would be anticipated.

The calculated maximum atmospheric concentrations of hazardous chemicals at the site boundary and onsite for the proposed action are presented in Table 5.7-5. The maximum concentrations at the site boundary are used to evaluate an exposure to a maximally exposed individual, whereas the maximum onsite concentrations could result in an exposure to a worker. Of the potential hazardous chemicals identified for the proposed action, cadmium, nickel and chromium VI (chrome) are carcinogens for which a total cancer risk was calculated. The remaining seven chemicals are noncarcinogens for which a hazard index was calculated. A hazard index value greater than 1 indicates a potential for adverse health effects.

Based on the maximum hazardous chemical concentrations at the site boundary, the lifetime fatal cancer risk and the hazard index to the maximally exposed member of the public would be only 5.4×10^{-13} and 2.5×10^{-3}, respectively. Based on the maximum concentrations onsite, the lifetime fatal cancer risk and hazard index to a worker would be only 2.7×10^{-12} and 1.3×10^{-2}, respectively. This indicates that there would be virtually no health impacts from nonradiological releases.

5.12.1.5 Industrial Safety. The measures of impacts for workplace hazards used in this analysis are (1) total reportable injuries and illnesses and (2) non-exposure-related fatalities in the work place.

Based on hazard rates for personnel of DOE and its contractors, it is estimated that 270 injuries and illnesses would be reported and 0.48 fatality would occur from all SNF construction activities. It is further estimated that 807 injuries and illnesses would be reported and 0.81 fatality would occur among SNF workers during lifetime operations.

5.12.2 Regionalization Alternative

Under the Regionalization Alternative, the radiological and nonradiological doses from operation of the proposed SNF facilities at the NTS could generally be lower than those described under the centralization alternative. Any corresponding health effects may also decrease.

5.13 Utilities and Energy

Direct changes in utility demand as a result of the Centralization and Regionalization Alternatives were compared, depending on available data, against either projected 1995 demand or the peak usage for the years 1988 through 1992 for each utility resource. Since utility usage at NTS is projected to decrease, this comparison is conservative. Impacts to provision of a utility are considered to occur if the demand for a utility is equal to or exceeds the available capacity within the designated Region of Influence. For the purpose of analysis, the Region of Influence for each resource is defined as the area served by the utility provider responsible for meeting the service demands of the NTS.

5.13.1 Centralization Alternative

5.13.1.1 Water Consumption. For the Centralization Alternative, approximately 0.43 liter per second (6.85 gallons per minute) of water would be required to operate the modules within the facility (Harr 1994). The 14 active wells had a capacity of 387 liters per second (6,139 gallons per minute) in 1993 (DOE/NV 1993a). The SNF facilities would require 0.1 percent of this amount. NTS wells would operate at 35 percent of total capacity, when the 1989 peak water usage of 134 liters per second (2,125 gallons per minute) was combined with the SNF facility requirements.

The active wells at Area 5 have a capacity of 38 liters per second (595 gallons per minute) (DOE/NV 1994c). The SNF facilities under the Centralization Alternative would require 1 percent of this amount. Water usage in Area 5 would increase to approximately 33 percent of the pump yield if the 1993 water usage of 12 liters per second (191 gallons per minute) for Area 5 is combined with the SNF facility requirements under the Centralization Alternative.

5.13.1.2 Electrical Consumption. Under the Centralization Alternative, the SNF facilities would require approximately 23,000 megawatt hours of electricity per year, or approximately 2.63 megavolt-amperes average demand (Harr 1994). The annual consumption of electricity of the SNF facilities would be approximately 12 percent of the 1995 annual consumption of electricity at NTS. The average electric demand of the SNF facilities would represent 6 to 7 percent of the projected 1995 peak electrical capacity of NTS. The average electric demand of the SNF facilities, combined with the peak electric demand of 39.5 megavolt-amperes, would utilize 94 to 105 percent of the transmission lines' current capacity. The 2.63 megavolt-amperes required for the SNF facility represents approximately 61 percent of the operating capacity of the substation at Area 5. The energy requirements of the SNF facility under the Centralization Alternative combined with the 1993 electric demand on the Frenchman Flat substation would utilize 63 percent of the substation capacity. It might be necessary to construct additional transmission lines or another substation to support the SNF facilities.

5.13.1.3 Fuel Consumption. Energy requirements for the SNF facilities under the Centralization Alternative were calculated assuming electrical power purchased from a utility was the primary source of energy; however, fossil fuels may be used to power backup generators and during construction activities. The amount of fuel that would be required for these operations would have little effect on fossil fuel usage at the NTS site.

5.13.1.4 Wastewater Disposal. Under the Centralization Alternative, approximately 0.43 liter per second (6.85 gallons per minute) of wastewater would be generated (Harr 1994). Currently, Area 5 has no wastewater facilities. A sewage treatment facility would need to be constructed for the SNF facilities under the Centralization Alternative.

5.13.2 Regionalization Alternative

The proposed SNF facilities under the Regionalization Alternative could consume less water, electricity, and fuel than under the Centralization Alternative. Less wastewater may also be generated; however, a sewage treatment facility would still need to be constructed.

5.14 Materials and Waste Management

Operation of the proposed SNF facilities would contribute transuranic, solid low-level, and sanitary waste as a consequence of transport, receipt, unloading, handling, and storage at the NTS. Under the SNF program, sources of potential contaminants would continue to be limited to construction support and site operation activities.

SNF storage activities would require the use of chemicals, and the majority of these would be expected to eventually become waste. Provisions would have to be made for the storage of the chemical raw materials used within the SNF complex as well as the waste material resulting from use. It was conservatively assumed that all chemical raw materials used by SNF would become hazardous wastes. Table 5.14-1 presents the estimated waste generation by waste classification for each of the two alternatives (Centralization and Regionalization) and by each of the two options (wet storage and dry storage).

5.14.1 Centralization Alternative

The Centralization Alternative would generate the greatest amount of waste from the SNF complex, since it is the alternative that contributes the larger amount of spent nuclear fuel to be stored. On an annual basis, the amount of waste generated by the SNF complex for this alternative would generally be greater than under the Regionalization Alternative. The handling capacity of the SNF complex is the factor that determines the amount of waste generation.

Table 5.14-1. Ten-year cumulative estimated waste generation for SNF alternatives at the NTS (m^3).

Time Period	1995-2004	2005-2014	2015-2024	2025-2034
	Centralization Alternative			
	Wet Storage Option			
Transuranic waste	160	160	160	160
Low-level waste	1,950	1,950	1,950	1,950
Hazardous waste	7.4×10^1	7.4×10^1	7.4×10^1	7.4×10^1
Sanitary waste	1.2×10^5	1.2×10^5	1.2×10^5	1.2×10^5
	Dry Storage Option			
Low-level waste	76	76	76	76
Sanitary waste	1.9×10^4	1.9×10^4	1.9×10^4	1.9×10^4
	Regionalization Alternative			
	Wet Storage Option			
Transuranic waste	<160	<160	<160	<160
Low-level waste	<1,950	<1,950	<1,950	<1,950
Hazardous	$<7.4 \times 10^1$	$<7.4 \times 10^1$	$<7.4 \times 10^1$	$<7.4 \times 10^1$
Sanitary waste	$<1.2 \times 10^5$	$<1.2 \times 10^5$	$<1.2 \times 10^5$	$<1.2 \times 10^5$
	Dry Storage Option			
Low-level waste	<76	<76	<76	<76
Sanitary waste	$<1.9 \times 10^4$	$<1.9 \times 10^4$	$<1.9 \times 10^4$	$<1.9 \times 10^4$

Source: Harr (1994).

5.14.1.1 Wet Storage Option.

5.14.1.1.1 Transuranic Waste — A small quantity (16 cubic meters, or 20.9 cubic yards) of transuranic waste would be generated per year due to the recovery and purification of transuranic products from the wet storage option (Harr 1994). Placement of this waste into the transuranic waste storage cell would have minimal impact on the current transuranic waste management at the NTS.

5.14.1.1.2 Low-Level Waste — The wet storage option would contribute liquid low-level waste as a result of its interim storage in water. This underwater storage would require filtered and deionized water to prevent possible corrosion problems with fuel elements and storage hardware; further waste would be generated from deionizer resin regeneration, filter backflushing, and chemical cleaning of the filter. An estimated 195 cubic meters (255 cubic yards) per year of low-level waste would be generated due to operation of the wet storage facility. Placement of this waste into the Radioactive Waste Management Site would be a viable option (see subsection 4.15.3). This quantity of low-level waste represents a minimal impact to the management of low-level waste at the NTS.

5.14.1.1.3 Hazardous Waste — Installation of the SNF complex would require additional management of hazardous wastes, including the placement of satellite storage areas within the SNF complex and more frequent offsite shipments of hazardous waste. An evaluation of the impact that the additional hazardous wastes generated by the wet storage option would be conducted as part of the required National Environmental Policy Act evaluation.

Additional hazardous waste accumulated would be transferred to the Hazardous Waste Accumulation Site, collected, and removed to an offsite EPA-permitted treatment, storage, and disposal facility. The potential for hazardous waste to adversely affect the environment as a result of an accidental spill would be limited due to the great depth to groundwater and the arid climate, thereby minimizing the likelihood of migration of surface and shallow subsurface contamination. Similarly, any leaks from new underground or aboveground storage tanks would have limited potential to affect the environment (DOE/NV 1992c).

It is estimated that the wet storage option would generate approximately 7.4 cubic meters (9.7 cubic yards) of hazardous waste annually. This quantity of hazardous waste represents a minimal impact to the management of hazardous wastes at the NTS.

5.14.1.1.4 Sanitary Waste—The SNF wet storage option would generate approximately 1.2 x 10^4 cubic meters (15,696 cubic yards) of sanitary waste annually. This quantity of sanitary waste would double the current sanitary waste disposal quantity at the NTS. This would require construction of additional septic/leach field capacity and/or additional sewage lagoon capacity, creating the need for additional land area for sanitary waste disposal.

5.14.1.2 Dry Storage Option. Unless a hazardous material were added to the fuel at the point of origination, hazardous material or mixed hazardous wastes would not be expected to be produced at a dry storage facility. With administrative controls applied at the storage facility to prevent hazardous material from coming in, the generation of mixed hazardous waste could be reduced or precluded. Any hazardous liquid and solid waste produced at the dry storage facility would be collected in a satellite accumulation area located inside the facility. Mixed waste would be stored onsite unless offsite storage and disposal facilities were licensed to accept radioactive waste.

Nonradioactive hazardous waste, such as oils, solvents, gloves, rags, and other materials associated with plant operation and maintenance, would be stored onsite until there were enough containers for shipment to an approved offsite treatment, storage, and disposal facility (Hale 1994).

5.14.1.2.1 Low-Level Waste—The low-level radioactive contaminated waste stream would result mainly from wastes generated during the decontamination operations of the cask, crane, and contaminated areas, from disposed personal protective equipment and clothing that would be used and disposed of during decontamination operations, and from the filters and ion exchange resins used to decontaminate the decontamination liquids. This waste would be sent to the waste packaging unit, where it would be compacted into drums for disposal. Old cans and lids removed in the canning process would be collected and placed into solid waste containers (Hale 1994). Approximately 7.6 cubic meters (9.9 cubic yards) of low-level waste would be

generated annually from the dry storage facility. This quantity of low-level waste represents a minimal impact to the management of low-level waste at the NTS.

5.14.1.2.2 Sanitary Waste—Sanitary sewage is the only liquid effluent to be released from the facility. The SNF dry storage option would generate approximately 1.9 x 10^3 cubic meters (2.5 x 10^3 cubic yards) of sanitary waste annually. This quantity of sanitary waste would double the current sanitary waste disposal quantity at the NTS. This would require construction of additional septic/leach field capacity and/or additional sewage lagoon capacity, creating the need for additional land area for sanitary waste disposal.

5.14.2 Regionalization Alternative

The Regionalization Alternative would generate less waste from the SNF facility than would the Centralization Alternative, since it would contribute the smaller amount of SNF to be stored. The handling capacity of the SNF complex determines the amount of waste generation. For either the wet storage option or dry storage option, the wastes generated would be less than those presented for the Centralization Alternative. Therefore, Table 5.14-1 presents the estimated waste generation for SNF for this alternative as less than that generated for the Centralization Alternative. The impacts presented for each of the waste categories for the Centralization Alternative apply to the Regionalization Alternative as well.

5.15 Facility Accidents

A potential exists for accidents at facilities associated with the handling, inspection, and storage of spent nuclear fuel at the NTS. Accidents can be categorized into events that are abnormal (for example, minor spills), events a facility was designed to withstand, and events a facility is not designed to withstand. These categories are termed *abnormal, design basis, and beyond design basis* accidents, respectively. Summarized here are consequences of possible facility accidents for a member of the public at the nearest site boundary and at the nearest road, for the collective population within 80 kilometers (50 miles), for workers, and for the environment. See Section 5.11 for a summary of the assessment of transportation accidents.

A review of the historical record of accidents at the NTS is summarized in the following section. Methods used to assess potential future events are summarized in Section 5.15.2. Evaluations of accident impacts by alternative are summarized in Section 5.15.3 through 5.15.7. A summary comparison of accident impacts by alternative is given in Section 3.2. Additional supporting documentation for the accident impacts is given in a separate report (HNUS 1995).

This section examines the various activities that have been performed to assess the potential for accidents and their consequences for workers and the public for each alternative. A set of potential reasonably forseeable accidents over the 40-year period are described which envelop all accidents. Secondary impacts of accidents pertaining to cultural resources, economics, land use, endangered species, water resources, and ecology are also addressed. This section also covers emergency preparedness plans that have been established to mitigate the primary and secondary effects of accidents.

5.15.1 Historical SNF Accidents at NTS

There have been no SNF operations in the past several years at the NTS upon which to base an accident history.

5.15.2 Methodology

There are no facilities currently at the NTS for receiving, handling and storage of SNF that can be used as a basis for accident analysis. In the absence of suitable design details for the proposed SNF facilities during this stage of the SNF Management Program upon which to base an accident analysis, the approach makes use of accident scenarios and associated data that have been analyzed and documented for similar facilities. They include spent nuclear fuel facilities at INEL, the Hanford Site, SRS, and Naval sites.

5.15.2.1 Assumptions and Approach. A number of postulated accidents for similar facilities have been selected to serve as a common basis for estimating accident consequences for workers and the public at the NTS. Although the accident scenarios, source terms, and related assumptions are similar to those for other sites, the estimated consequences are unique to the

NTS because of site differences in modeling parameters pertaining to distances to site boundaries and population centers, population distributions, and meteorology. The GENII code (PNL 1988) was used to estimate accident consequences for the general public and for individuals onsite or at the site boundary, based on both 50 percent and 95 percent meteorology. Accident consequences and risk are described in terms of dose, latent cancer fatalities, and total health detriments for workers, for an individual at the site boundary, for a transient individual at the nearest public access, and for the public residing out to 80 kilometers (50 miles) from the proposed SNF facility. The estimated frequency of each selected accident is based on the reference source documentation.

The probability of an airplane crash into the facility is considered very small, because there are no nearby airports with large aircraft activity. For calculational purposes, the probability of such an accident is conservatively estimated at 10^{-6} per year. Potential accidents initiated by an airplane crash into the SNF facilities and the estimated consequences have been analyzed.

The secondary impacts of accidental releases of radioactive and hazardous materials are also addressed in a qualitative manner. Secondary impacts pertain to effects of accidents on land use, endangered species, water resources, cultural resources, and ecology.

5.15.2.2 Accident Screening. The potential accidents associated with existing SNF facilities and operations were screened to determine which ones to include in the accident analysis for the NTS. The source documentation for this effort was primarily Appendices A, B, C, and D of Volume 1 that were selected by a screening process for existing SNF facilities. Initiating events were reviewed, including natural phenomena (e.g., earthquakes and tornadoes) and human-initiated events (e.g., human error, equipment failures, fires, explosives, plane crashes, and terrorism). Accidents associated with Expended Core Facility (ECF) operations at the NTS were analyzed separately, and the results are documented in Appendix D. For the NTS the maximum reasonably foreseeable criticality and nonradiological accidents are associated with the ECF. The potential for a criticality exists while the fuel is in dry storage, during handling, and in the wet storage pool. Although the probability of any criticality is very low, a hypothetical criticality of 1×10^{19} fissions was postulated in the ECF wet pool as a basis for estimating the maximum reasonably foreseeable consequences of a criticality.

The selected accidents include beyond-design-basis events in order to reflect the magnitude of accident consequences that envelop all other accidents having a reasonable probability of occurrence. They also include other accidents with lower consequences and typically higher probabilities of occurrence, to show a range of accident types and consequences. The accidents included in this set are reasonably foreseeable, meaning that there are one or more sequences of events that will lead to their occurrence, and the sequence with the highest probability of occurrence is greater than 1 x 10^{-7} per year. Accidents falling outside of this envelope, such as a meteorite impact, have been judged unreasonable because the probability of occurrence of less than 1 x 10^{-7} per year.

5.15.2.3 Accident Prevention and Mitigation. Under the Centralization and Regionalization Alternatives, the proposed SNF facilities at the NTS will be of new design and construction and incorporate the latest technology for safety. The accidents postulated for the SNF facilities are based on operations and safety analyses that have been performed at similar facilities. One of the major design goals for the proposed SNF facilities is to achieve a reduced risk to facility personnel and to public health and safety relative to that associated with similar functions at existing SNF facilities. Significant improvements would exist between the design criteria and safety standards of the new SNF facilities and those for the current facilities, reducing total risk. These would include changes in design to current DOE structural and safety criteria and to planned throughput and storage capacity.

The SNF facilities would be designed to comply with current Federal, state, and local laws, DOE Orders, and industrial codes and standards. This would provide facilities that are highly resistant to the effects of severe natural phenomena, including earthquakes, floods, tornadoes, high winds, as well as credible events as appropriate to the site, such as fires and explosions, and man-made threats to its continuing structural integrity for containing materials.

An emergency preparedness plan will also be prepared to lower the potential consequences of an accident to workers and the public. All workers receive evacuation training to ensure timely and orderly personnel movement away from high-risk areas. Plans and arrangements with local authorities will also be inplace to evacuate the general public that may be at risk of exposure to hazardous materials that are accidently released.

5.15.3 No Action Alternative

There are currently no SNF operations at NTS. The No Action Alternative is not applicable for NTS.

5.15.4 Centralization Alternative

There is a potential for the accidental release of radioactive substances during various stages of SNF handling operations and storage. The operations begin with the receipt of an SNF shipment by truck or rail carrier followed by the unloading of the shipping cask from the transport vehicle. If the SNF requires cooling, the cask is placed into an unloading pool where the SNF is withdrawn from the cask, moved to a temporary wet storage basin, and placed into a fuel rack. Some SNF that does not require cooling will be handled in a special cell, where it will undergo canning and/or characterization. SNF that does not have to be cooled and does not require canning and/or characterization will be loaded into a dry storage canister within a transfer cask and transported to modular above-grade dry storage. Accidents that may occur during these handling operations and storage may involve the release of radioactive material to air or water pathways. The cause of accidents may be due to internal initiators, such as operator error, terrorism, and equipment failure or external initiators, such as an aircraft crash into a facility.

5.15.4.1 Radiological Impacts. The set of accidents described below have been chosen to envelop the consequences of potential accidents for the proposed SNF facilities at the NTS. Although other accidents may occur, their estimated consequences are bounded by the accidents in the envelop or their probability of occurrence would be less than 1 x 10^{-6} per year. If such accidents were to occur, the dose and risk would be as shown in Tables 5.15-1 and 5.15-2 for 95 percent and 50 percent meteorology, respectively. Similarly, cancer fatalities are shown in Tables 5.15-3 and 5.15-4, and the health effects are shown in Tables 5.15-5 and 5.15-6.

5.15.4.1.1 Fuel Assembly Breach—Physical damage and breach of a fuel assembly could accidentally occur from its being dropped, from objects falling on it, or from the fuel part being cut. The fuel-cutting accident that has been postulated to occur at SRS SNF facilities is

Table 5.15-1. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Nevada Test Site at 95 percent meteorology.

		95 Percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b] (rem)	Worker[c] (rem)	Population (person-rem)	MEI (rem/yr)	NPAI (rem/year)	Worker (rem/yr)	Population (person-rem/yr)
Fuel assembly breach	1.6×10^{-1} [d]	2.0×10^{-3}	1.9 x 10-5	1.5×10^{-3}	1.3×10^{0}	3.2×10^{-4}	3.0×10^{-6}	2.4×10^{-4}	2.1×10^{-1}
Dropped fuel cask	1.0×10^{-4} [e]	1.3×10^{0}	2.7×10^{-2}	4.7×10^{0}	2.8×10^{2}	1.3×10^{-4}	2.7×10^{-6}	4.7×10^{-4}	2.8×10^{-2}
Severe impact and fire	1.0×10^{-6} [f]	9.3×10^{0}	9.9×10^{-2}	3.5×10^{0}	5.8×10^{3}	9.3×10^{-6}	9.9×10^{-8}	3.5×10^{-6}	5.8×10^{-3}
Wind-driven missile impact into dry storage	1.0×10^{-5}	3.5×10^{-3}	3.2×10^{-4}	1.2×10^{-2}	5.7×10^{-1}	3.5×10^{-8}	3.2×10^{-9}	1.2×10^{-7}	5.7×10^{-6}
Airplane crash into dry storage	1.0×10^{-6} [f]	1.5×10^{0}	7.7×10^{-2}	1.2×10^{1}	5.6×10^{2}	1.5×10^{-6}	7.7×10^{-8}	1.2×10^{-5}	5.6×10^{-4}
Airplane crash into dry cell facility	1.0×10^{-6} [f]	1.2×10^{1}	2.4×10^{-1}	2.3×10^{1}	7.0×10^{3}	1.2×10^{-5}	2.4×10^{-7}	2.3×10^{-5}	7.0×10^{-3}
Airplane crash into water pool	1.0×10^{-6} [f]	2.2×10^{-2}	1.4×10^{-4}	2.4×10^{-2}	5.8×10^{1}	2.2×10^{-8}	1.4×10^{-10}	2.4×10^{-8}	5.8×10^{-5}

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

e. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

f. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-2. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Nevada Test Site at 50 percent meteorology.

		50 Percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b] (rem)	Worker[c] (rem)	Population[d] (person-rem)	MEI (rem/yr)	NPAI (rem/year)	Worker (rem/yr)	Population (person-rem/yr)
Fuel assembly breach	1.6×10^{-1} [e]	5.0×10^{-5}	2.9×10^{-7}	4.7×10^{-5}	3.4×10^{-2}	8.0×10^{-6}	4.6×10^{-8}	7.5×10^{-6}	5.4×10^{-3}
Dropped fuel cask	1.0×10^{-4} [f]	3.2×10^{-2}	4.1×10^{-4}	1.5×10^{-1}	6.9×10^{0}	3.2×10^{-6}	4.1×10^{-8}	1.5×10^{-5}	6.9×10^{-4}
Severe impact and fire	1.0×10^{-6} [g]	2.3×10^{-1}	1.5×10^{-3}	1.1×10^{-1}	1.4×10^{2}	2.3×10^{-7}	1.5×10^{-9}	1.1×10^{-7}	1.4×10^{-4}
Wind-driven missile into dry storage area	1.0×10^{-5}	8.7×10^{-5}	4.7×10^{-6}	3.7×10^{-4}	1.3×10^{-2}	8.7×10^{-10}	4.7×10^{-11}	3.7×10^{-9}	1.3×10^{-7}
Airplane crash into dry storage	1.0×10^{-6} [g]	3.7×10^{-2}	1.2×10^{-3}	3.9×10^{-1}	1.4×10^{1}	3.7×10^{-8}	1.2×10^{-9}	3.9×10^{-7}	1.4×10^{-5}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	3.1×10^{-1}	3.7×10^{-3}	7.4×10^{-1}	1.7×10^{2}	3.1×10^{-7}	3.7×10^{-9}	7.4×10^{-7}	1.7×10^{-4}
Airplane crash into water pool	1.0×10^{-6} [g]	5.6×10^{-4}	2.0×10^{-6}	7.4×10^{-4}	1.4×10^{0}	5.6×10^{-10}	2.0×10^{-12}	7.4×10^{-10}	1.4×10^{-6}

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. Dose received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-3. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Nevada Test Site at 95 percent meteorology.

		95 Percent meteorology							
Accident scenario	Frequency (per year)	Cancer fatalities				Cancer fatality risk (cancer fatalities/yr)			
		MEI[a]	NPAI[b]	Worker[c]	Population[d]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [e]	9.8×10^{-7}	9.3×10^{-9}	6.0×10^{-7}	6.6×10^{-4}	1.6×10^{-7}	1.5×10^{-9}	9.6×10^{-8}	1.1×10^{-4}
Dropped fuel cask	1.0×10^{-4} [f]	6.4×10^{-4}	1.4×10^{-5}	1.9×10^{-3}	2.8×10^{-1}	6.4×10^{-8}	1.4×10^{-9}	1.9×10^{-7}	2.8×10^{-5}
Severe impact and fire	1.0×10^{-6} [g]	4.7×10^{-3}	5.0×10^{-5}	1.4×10^{-3}	5.8×10^{0}	4.7×10^{-9}	5.0×10^{-11}	1.4×10^{-9}	5.8×10^{-6}
Wind-driven missile impact into dry storage	1.0×10^{-5}	1.7×10^{-6}	1.6×10^{-7}	4.9×10^{-6}	2.9×10^{-4}	1.7×10^{-11}	1.6×10^{-12}	4.9×10^{-11}	2.9×10^{-9}
Airplane crash into dry storage	1.0×10^{-6} [g]	7.4×10^{-4}	3.9×10^{-5}	4.8×10^{-3}	5.6×10^{-1}	7.4×10^{-10}	3.9×10^{-11}	4.8×10^{-9}	5.6×10^{-7}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	6.1×10^{-3}	1.2×10^{-4}	1.8×10^{-2}	7.0×10^{0}	6.1×10^{-9}	1.2×10^{-10}	1.8×10^{-8}	7.0×10^{-6}
Airplane crash into water pool	1.0×10^{-6} [g]	1.1×10^{-5}	7.1×10^{-8}	9.6×10^{-6}	5.8×10^{-2}	1.1×10^{-11}	7.1×10^{-14}	9.6×10^{-12}	5.8×10^{-8}

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

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Table 5.15-4. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Nevada Test Site at 50 percent meteorology.

		50 Pecent meteorology							
		Cancer fatalities				Cancer fatality risk (cancer fatalities/yr)			
Accident scenario	Frequency (per year)	MEI[a]	NPAI[b]	Worker[c]	Population[d]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [e]	2.5×10^{-8}	1.4×10^{-10}	1.9×10^{-8}	1.7×10^{-5}	4.0×10^{-9}	2.2×10^{-11}	3.0×10^{-9}	2.7×10^{-6}
Dropped fuel cask	1.0×10^{-4} [f]	1.6×10^{-5}	2.1×10^{-7}	6.0×10^{-5}	3.5×10^{-3}	1.6×10^{-9}	2.1×10^{-11}	6.0×10^{-9}	3.5×10^{-7}
Severe impact and fire	1.0×10^{-6} [g]	1.2×10^{-4}	7.5×10^{-7}	4.5×10^{-5}	1.4×10^{-1}	1.2×10^{-10}	7.5×10^{-13}	4.5×10^{-11}	1.4×10^{-7}
Wind-driven missile impact into dry storage	1.0×10^{-5}	4.4×10^{-8}	2.4×10^{-9}	1.5×10^{-7}	6.7×10^{-6}	4.4×10^{-13}	2.4×10^{-14}	1.5×10^{-12}	6.7×10^{-11}
Airplane crash into dry storage	1.0×10^{-6} [g]	1.8×10^{-5}	6.0×10^{-7}	1.6×10^{-4}	6.8×10^{-3}	1.8×10^{-11}	6.0×10^{-13}	1.6×10^{-10}	6.8×10^{-9}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	1.5×10^{-4}	1.9×10^{-6}	3.0×10^{-4}	1.7×10^{-1}	1.5×10^{-10}	1.9×10^{-12}	3.0×10^{-10}	1.7×10^{-7}
Airplane crash into water pool	1.0×10^{-6} [g]	2.8×10^{-7}	1.0×10^{-9}	3.0×10^{-7}	7.0×10^{-4}	2.8×10^{-13}	1.0×10^{-15}	3.0×10^{-13}	7.0×10^{-10}

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-5. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Nevada Test Site at 95 percent meteorology.

		95 Percent meteorology							
		Total health detriments[a]				Total health detriment risk (detriments/yr)			
Accident scenario	Frequency (per year)	MEI[b]	NPAI[c]	Worker[d]	Population[e]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [f]	1.4×10^{-6}	2.1×10^{-10}	8.4×10^{-7}	9.7×10^{-4}	2.2×10^{-7}	3.4×10^{-11}	1.3×10^{-7}	1.6×10^{-4}
Dropped fuel cask	1.0×10^{-4} [g]	9.3×10^{-4}	3.0×10^{-7}	2.6×10^{-3}	4.1×10^{-1}	9.3×10^{-8}	3.0×10^{-11}	2.6×10^{-7}	4.1×10^{-5}
Severe impact and fire	1.0×10^{-6} [h]	6.8×10^{-3}	1.1×10^{-6}	2.0×10^{-3}	8.5×10^{0}	6.8×10^{-9}	1.1×10^{-12}	2.0×10^{-9}	8.5×10^{-6}
Wind-driven missile impact into dry storage	1.0×10^{-5}	2.5×10^{-6}	3.4×10^{-9}	6.9×10^{-6}	4.2×10^{-4}	2.5×10^{-11}	3.4×10^{-14}	6.9×10^{-11}	4.2×10^{-9}
Airplane crash into dry storage	1.0×10^{-6} [h]	1.1×10^{-3}	8.8×10^{-7}	6.7×10^{-3}	8.2×10^{-1}	1.1×10^{-9}	8.8×10^{-13}	6.7×10^{-9}	8.2×10^{-7}
Airplane crash into dry cell facility	1.0×10^{-6} [h]	8.9×10^{-3}	2.7×10^{-6}	2.6×10^{-2}	1.0×10^{1}	8.9×10^{-9}	2.7×10^{-12}	2.6×10^{-8}	1.0×10^{-5}
Airplane crash into water pool	1.0×10^{-6} [h]	1.6×10^{-5}	1.5×10^{-9}	1.3×10^{-5}	8.5×10^{-2}	1.6×10^{-11}	1.5×10^{-15}	1.3×10^{-11}	8.5×10^{-8}

a. Maximum exposed individual (MEI). The estimated number of cancer fatalities, cancer non fatalities, and genetic defects resulting from the radiation exposure.

b. Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure received from inhalation, external, and ingestion pathways.

f. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

g. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

h. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-6. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Nevada Test Site at 50 percent meteorology.

		50 Percent meteorology							
		Total health detriments[a]				Total health detriment risk (detriments/yr)			
Accident scenario	Frequency (per year)	MEI[b]	NPAI[c]	Worker[d]	Population[e]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [f]	3.7×10^{-8}	1.4×10^{-8}	2.6×10^{-8}	2.5×10^{-5}	5.9×10^{-9}	2.2×10^{-9}	4.2×10^{-9}	4.0×10^{-6}
Dropped fuel cask	1.0×10^{-4} [g]	2.3×10^{-5}	2.0×10^{-5}	8.4×10^{-5}	5.1×10^{-3}	2.3×10^{-9}	2.0×10^{-9}	8.4×10^{-9}	5.1×10^{-7}
Severe impact and fire	1.0×10^{-6} [h]	1.7×10^{-4}	7.2×10^{-5}	6.2×10^{-5}	2.1×10^{-1}	1.7×10^{-10}	7.2×10^{-11}	6.2×10^{-11}	2.1×10^{-7}
Wind-driven missile impact into dry storage	1.0×10^{-5}	6.4×10^{-8}	2.3×10^{-7}	2.1×10^{-7}	9.7×10^{-6}	6.4×10^{-13}	2.3×10^{-12}	2.1×10^{-12}	9.7×10^{-11}
Airplane crash into dry storage	1.0×10^{-6} [h]	2.7×10^{-5}	5.6×10^{-5}	2.2×10^{-4}	9.9×10^{-3}	2.7×10^{-11}	5.6×10^{-11}	2.2×10^{-10}	9.9×10^{-9}
Airplane crash into dry cell facility	1.0×10^{-6} [h]	2.2×10^{-4}	1.8×10^{-4}	4.2×10^{-4}	2.5×10^{-1}	2.2×10^{-10}	1.8×10^{-10}	4.2×10^{-10}	2.5×10^{-7}
Airplane crash into water pool	1.0×10^{-6} [h]	4.1×10^{-7}	1.0×10^{-7}	4.1×10^{-7}	1.0×10^{-3}	4.1×10^{-13}	1.0×10^{-13}	4.1×10^{-13}	1.0×10^{-9}

a. Maximum exposed individual (MEI). The estimated number of cancer fatalities, cancer non fatalities, and genetic defects resulting from the radiation exposure.

b. Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure received from inhalation, external, and ingestion pathways.

f. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

g. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

h. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

chosen as representative of the fuel assembly breach accident (E. I. du Pont de Nemours & Co. 1983). During normal SRS operations, the inert, non-uranium-containing extremities of some SNF elements are cut off in the repackaging basin before the elements are bundled. The accident occurs when the actual uranium fuel is inadvertently cut, causing a radioactive release. The source term for this accident is shown in Table 5.15-7. The estimated frequency of occurrence for this accident is 1.6×10^{-1} per year, based on SRS operating experience with SNF. Because of anticipated differences in operations and facilities at the NTS, however, the actual frequency is expected to be much less than 1.6×10^{-1} per year.

5.15.4.1.2 Dropped Fuel Cask—The dropped fuel cask accident that has been postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the dropped fuel cask/fuel handling accident for the new Centralization Alternative facility at NTS. This accident is initiated when a fuel cask is dropped and overturned in the fuel transfer area. Broken fuel elements spill out of the cask, within the pool building but away from the pool. It is assumed that the shipping cask ruptures, exposing all of the broken fuel elements in three canisters: 42 fuel elements, each containing 22.5 kilograms (50 pounds) of fuel. The source term for this accident is shown in Table 5.15-8. The probability of this accident is estimated to be less than 1×10^{-4} per year.

5.15.4.1.3 Severe Impact and Fire—The severe impact and fire accident that has been postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the severe impact and fire/onsite transportation accident for the new Centralization Alternative facility at NTS. This accident assumes an unspecified initiating event that subjects the fuel assemblies to a severe impact, breach of the transport cask, and a fire. During the accident, the fuel pins rupture on impact or upon heating in the fire, which burns for an hour before being extinguished. Volatiles, particulates, and noble gases are released to the atmosphere. The source term for a release of 540 curies is shown in Table 5.15-9. The estimated probability of occurrence for this accident, reflecting the fact that the facilities of this site would be new, is less than 1×10^{-6} per year.

5.15.4.1.4 Wind-driven Missile Impact into Storage Casks—The wind-driven missile impact into storage casks accident that has been postulated to occur at the Naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the wind-driven

Table 5.15-7. Estimated radionuclide releases for a fuel assembly breach accident at the NTS.[a]

Radionuclide	Release (Ci)
Iodine-131	7.1×10^{-2}
Iodine-133	1.4×10^{-30}
Krypton-85	1.8×10^{2}
Xenon-133m	1.1×10^{-8}
Xenon-133	1.1×10^{0}

a. Source: E. I. du Pont de Nemours & Co. (1983).

Table 5.15-8. Estimated radionuclide releases for a dropped fuel cask accident at the NTS.[a]

	Release (Ci)	
Radionuclide	Onsite (2 hours)	Offiste (8 hours)
Plutonium-236	1.3×10^{-8}	5.4×10^{-8}
Plutonium-238	2.9×10^{-3}	1.2×10^{-2}
Plutonium-239	6.7×10^{-3}	2.7×10^{-2}
Plutonium-240	3.5×10^{-3}	1.4×10^{-2}
Plutonium-241	2.7×10^{-1}	1.1×10^{0}
Plutonium-242	1.3×10^{-6}	5.1×10^{-6}
Americium-241	5.7×10^{-3}	2.3×10^{-2}
Curium-244	2.8×10^{-4}	1.1×10^{-3}
Europium-154	5.4×10^{-3}	2.1×10^{-2}
Cesium-134	7.9×10^{-3}	3.2×10^{-2}
Cesium-137	4.5×10^{-1}	1.8×10^{0}
Cerium-144	1.7×10^{-3}	6.8×10^{-3}
Praseodymium-144	1.7×10^{-3}	6.8×10^{-3}
Praseodymium-144m	2.0×10^{-5}	8.1×10^{-5}
Promethium-147	1.2×10^{-1}	4.9×10^{-1}
Antimony-125	7.3×10^{-3}	2.9×10^{-2}
Tellurium-125m	1.8×10^{-3}	7.3×10^{-3}
Ruthenium-106	3.2×10^{-3}	1.3×10^{-2}
Strontium-90	3.5×10^{-1}	1.4×10^{0}
Yttrium-90	3.5×10^{-1}	1.4×10^{0}

a. Source: Volume 1, Appendix A, Table A-1.

Table 5.15-9. Estimated radionuclide releases for a severe impact and fire accident at the NTS.[a]

Radionuclide	Release (Ci)
Tritium	4.6×10^{1}
Krypton-85	4.0×10^{2}
Strontium-90	2.7×10^{-2}
Ruthenium-106	1.3×10^{0}
Cesium-134	1.7×10^{1}
Cesium-137	8.0×10^{1}
Plutonium-238	8.9×10^{-4}
Plutonium-239	1.6×10^{-3}
Plutonium-240	1.8×10^{-3}
Plutonium-241	7.3×10^{-2}
Americium-241	1.0×10^{-3}

a. Source: Volume 1, Appendix A, Table A-14.

missile accident for the new Centralization Alternative facility at NTS. This accident is initiated by natural phenomena, a major wind storm or tornado in excess of facility design basis. In this scenario, a large object is propelled by the wind into a storage container, causing the container seal to be breached. No fuel damage results from the impact because of the strength of the containers used. The source term is based on the spent nuclear fuel corrosion film. One percent of the original corrosion film on the fuel is released from the cask to the atmosphere. The source term is shown in Table 5.15-10. The probability of this event is estimated to be less than 1×10^{-5} per year, based on a design basis tornado probability of 1×10^{-3} per year and a missile impact with damage probability of less than 1×10^{-2}.

5.15.4.1.5 Airplane Crash Into Dry Storage—The airplane crash into dry storage accident that has been postulated to occur at the Naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the dry storage area accident for the new Centralization Alternative facility at NTS. This accident initiated by an airplane crash into the SNF dry storage facility. The accident is postulated to cause damage to a single storage cask. Due to the severity of the impact, the cask seal is assumed to be breached, resulting in damage to the fuel and the release of corrosion products, located on the SNF exterior, to the environment. The impact also causes a fire and a release of fission products. It is assumed that 1 percent of all of the fuel units stored inside the cask are damaged either by the impact or by the fire, and that those fission products are available for release. Of the available fission products, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids are released to the environment. Also, 10 percent of the original corrosion products from the fuel units are released from the cask to the atmosphere. The source term for this accident is shown in Table 5.15-11. The probability of this accident is small and is assumed to be less than 1×10^{-6} per year.

5.15.4.1.6 Airplane Crash into Dry Cell Facility—The airplane crash into the dry cell facility accident that has been postulated to occur at the naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the canning and characterization cell accident for the new Centralization Alternative facility at NTS. This accident is initiated by an airplane crash into the dry cell facility. The accident is postulated to cause significant damage to the building, resulting in the loss of containment and filtered exhaust

Table 5.15-10. Estimated radionuclide releases for a wind-driven missile impact into a storage cask at the NTS.[a]

Radionuclide	Release (Ci)
Cobalt-60	9.58×10^{-2}
Iron-55	1.76×10^{-1}
Cobalt-58	3.54×10^{-2}
Manganese-54	5.98×10^{-3}
Iron-59	5.11×10^{-4}

a. Source: Volume 1, Appendix D, Section F.1.4.2.2.1.

Table 5.15-11. Estimated radionuclide releases for an airplane crash into dry storage facility at the NTS.[a]

Radionuclide	Release (Ci)
Cesium-134	2.6×10^{1}
Cesium-137	3.6×10^{1}
Plutonium-238	5.9×10^{-2}
Barium-137m	3.1×10^{0}
Strontium-90	3.1×10^{0}
Cerium-144	7.2×10^{0}
Niobium-95	4.4×10^{0}
Yttrium-90	3.1×10^{0}
Ruthenium-106	6.1×10^{-1}

a. Source: Volume 1, Appendix D, Section F.1.4.2.2.2.

systems. The fuel units inside the dry cell are damaged by the impacts and fire. The impact also results in the release of corrosion products to the environment. For this accident scenario, 1 percent of the fuel units stored inside the dry cell are assumed to be damaged by either the impact or the resultant fire and those fission products would be available for release. Of the fission products available for release, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids are released to the environment. Ten percent of the available corrosion products are released to the environment. The source term for this accident is shown in Table 5.15-12. The probability of this accident is estimated to be less than 1×10^{-6} per year.

5.15.4.1.7 Airplane Crash into Water Pool—The airplane crash into the SNF water pool accident that has been postulated to occur at the Naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the SNF water pool accident for the new Centralization Alternative facility at NTS. This externally initiated accident occurs when an airplane crashes into an SNF water pool and damages the fuel units stored there. Fission products and corrosion products are released from the fuel units into the water pool, but the pool water is not released to the environment. The presence of the pool water results in only a release of gaseous fission products to the atmosphere. In this accident scenario 1 percent of all the fuel units stored inside the pool are postulated to be damaged and those fission products are available for release. Of the available fission products, 100 percent of the noble gases and 25 percent of the halogens are released to the pool water. Due to the presence of pool water, there is a reduction of the halogen release by a factor of 10 prior to release to the atmosphere. The source term for this accident is shown in Table 5.15-13. The probability of this accident is estimated to be less than 1×10^{-6} per year.

5.15.4.2 Nonradiological Hazards. The two bounding accidents involving nonradiological hazards are a chemical spill and fire and a diesel fuel fire. Both of these accidents are associated with the Expended Core Facility operations and the accident frequencies and impacts are addressed in Volume 1, Appendix D. The analyses of these accidents considered the impacts to workers on the site as well as to the offsite population. The impacts were measured in terms of potential heath effects due to exposure to toxic chemicals released during these accidents. Since the ECF at this site will be a new design and construction, it will incorporate all applicable

Table 5.15-12. Estimated radionuclide releases for an airplane crash into dry cell facility at the NTS.[a]

Radionuclide	Release (Ci)
Cesium-134	4.5×10^{1}
Cesium-137	6.2×10^{1}
Plutonium-238	1.0×10^{-1}
Barium-137m	5.4×10^{0}
Strontium-90	5.5×10^{0}
Cerium-144	1.3×10^{1}
Niobium-95	7.7×10^{0}
Yttrium-90	5.5×10^{0}
Ruthenium-106	1.1×10^{0}

a. Source: Volume 1, Appendix D, Section F.1.4.2.3.3.

Table 5.15-13. Estimated radionuclide releases for an airplane crash into an SNF water pool at the NTS.[a]

Radionuclide	Release (Ci)
Iodine-129	7.6×10^{-4}
Iodine-131	1.6×10^{-2}
Tritium	4.3×10^{2}

a. Source: Volume 1, Appendix D, Section F.1.4.2.1.4.

standards and regulations and therefore limit the potential exposures to the workers and the public in the event of an accident.

5.15.4.3 Secondary Impacts. In the event of an accidental release of radioactive substances, there is a potential for secondary impacts to cultural resources, endangered species, water resources, and public and agricultural land use, the ecology in the vicinity of the accident, national defense, and local economics. In order to assess the impacts, a severe accident and the resulting release of radioactive material were evaluated. The accident chosen for evaluation was an airplane crash into the Centralization Alternative canning and characterization (dry) cell. Utilizing the 50 percent meteorology and the typical flat topography of the proposed SNF site, the dispersion of radioactive material and the resulting dose were calculated. Figure 5.15-1 shows the isodose lines ranging from 870 millirem per year down to 87 millirem per year, which is approximately equivalent to cosmic and terrestrial background radiation. The farthest distance between the accident site and the 87 millirem per year line is 8,000 feet (2,400 meters). Therefore, in order to minimize the potential impact of an accident on the non-NTS personnel and the public, the SNF facility should be located at least 8,000 feet (2,400 meters) from the NTS boundary. Given the available space within Area 5 and the large buffer zone surrounding the proposed SNF site and the NTS, the final siting location could easily accommodate this design constraint. This design constraint could be applied to other environmental resources during the final siting process. The secondary impacts in other environmental resources which would not be accommodated as easily are summarized below. Table 5.15-14 presents a summary of the postulated severe accident secondary impacts on the environment, economy, and national defense. The evaluation was performed using 50 percent meteorology.

5.15.5 Decentralization Alternative

The Decentralization Alternative is not applicable for the NTS.

5.15.6 1992/1993 Planning and Basis Alternative

There are currently no SNF operations at NTS. The 1992/1993 Planning Basis Alternative is not applicable for NTS.

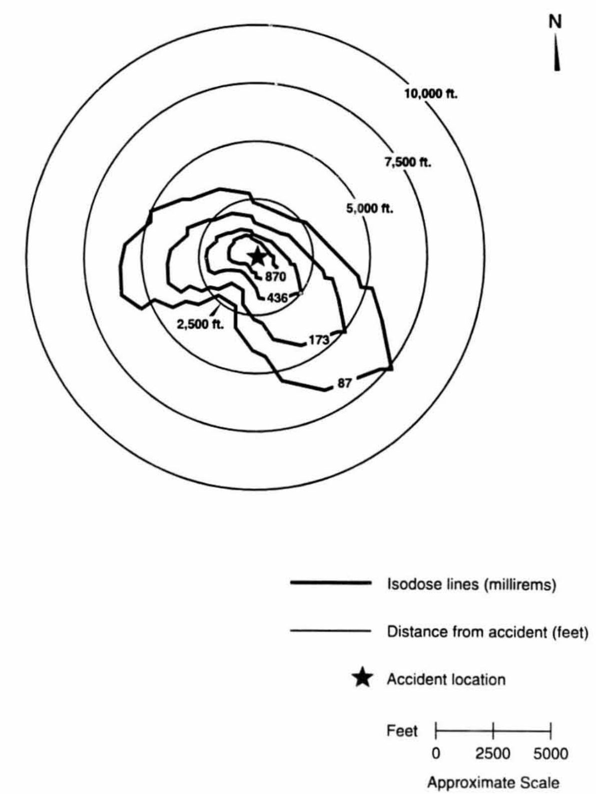

Figure 5.15-1. Typical Isodose lines for an airplane crash into a dry cell accident with 50 percent meteorology for northeastern Area 5 of the NTS.

Table 5.15-14. Secondary impacts of the Centralized Alternative accidents at NTS.

Environmental or social factor	Impact
Land Use	Possible minor impact. The dispersion of radioactive material would be limited within the NTS boundaries. The major NTS facilities in the vicinity of the proposed SNF site include the Radioactive Waste Management Site and the Liquified Gaseous Fuels Spill Test Facility.
Cultural Resources	Possible minor impact. Surveys conducted for other Area 5 activities have indicated only scattered artifacts in the vicinity of the proposed SNF site. No major prehistoric/historic sites are anticipated to be located in the vicinity of the proposed SNF site. Access to any random artifacts found during the accident investigation and cleanup would have to be restricted until radioactive decay had occurred.
Aesthetic and Scenic Resources	No impact. The area of contamination does not envelop aesthetic and scenic resources.
Water Resources	No impact. The nuclear testing program has dispersed radioactive material in the vicinity of the proposed SNF site during aboveground nuclear tests. Due to the great depths of the groundwater, the groundwater was not contaminated. It is anticipated that an accident would not alter the pathways to the groundwater.
Ecological Resources	Possible impact. Many threatened or endangered plants and animals, except fish species, are potentially on or near the NTS.
Treaty Rights	No impact. There are no onsite areas subject to Native American Treaty rights.
National Defense	No impact. The area of contamination does not envelop U.S. military or defense industry facilities.
Economic Impacts	Possible minor impact. The dispersion of radioactive material would be limited within the NTS boundaries. The major NTS facilities in the vicinity of the proposed SNF site include the Radioactive Waste Management Site and the Liquified Gaseous Fuels Spill Test Facility.

5.15.7 Regionalization Alternative

Under the Regionalization Alternative, new facilities would be constructed and operated for SNF. Details for the new facilities have not been defined, but it is reasonable to expect that they would be similar to but with less throughput and storage requirements than those needed for the Centralization Alternative. Due to smaller throughput and storage requirements, the potential for accidents (i.e., probability of occurrence) will be similar to but less than those described for the Centralization Alternative. The accident consequences would be similar for both alternatives. Consequently, it is reasonable to assume the accident consequences and risks described for the Centralization Alternative envelop the Regionalization Alternative.

5.15.8 Emergency Preparedness and Plans

DOE has issued a series of Orders specifying the requirements for emergency preparedness (DOE Orders 5500.1A, 5500.2A, 5500.3, draft 5500.3A, 5500.4, and 5500.9), and each DOE site has established an emergency management program. These programs are developed and maintained to ensure adequate response for most accident conditions and to provide the framework to readily extend response efforts for accidents not specifically considered. The emergency management program incorporates activities associated with planning, preparedness, and response.

Officials at each DOE site have specified the emergency preparedness requirements for the DOE facilities under their jurisdiction in a manner consistent with the relevant DOE Orders. All existing facilities have emergency plans and procedures that either implement the DOE and site requirements or are integrated with the site planning.

The Nevada Operations Office Emergency Preparedness Plan is designed to minimize or mitigate the impact of any emergency upon the health and safety of employees and the public. The plan integrates all emergency planning into a single entity to minimize overlap and duplication, and to ensure proper responses to emergencies not covered by a plan or directive. The plan is based upon the concept that the Manager, Nevada Operations Office, has the capability to manage, counter, and recover from an emergency occurring within the Nevada Operations Office responsibility.

The Nevada Operations Office plan provides for (1) identification and notification of personnel for any emergency that may develop during operational or nonoperational hours; (2) the receipt of warnings, weather advisories, or any other information that may provide advance warning of a possible emergency; and (3) prearranged actions which may be taken to minimize the effect of the emergency. The plan is based upon current Nevada Operations Office vulnerability assessments, resources, and capabilities regarding emergency preparedness.

5.16 Cumulative Impacts and Impacts from Connected or Similar Actions

The NTS already contains several major DOE and non-DOE facilities, unrelated to SNF, that would continue to operate throughout the operating life of the proposed SNF management facilities. The activities associated with these existing facilities produce environmental consequences that have been included in the baseline environmental conditions (Chapter 4) against which Sections 5.1 through 5.15 have assessed the environmental consequences of the Centralization and Regionalization Alternatives. This section uses the environmental baseline conditions presented in Chapter 4 to assess potential cumulative impacts from the proposed SNF management facilities, if constructed at the NTS, plus other reasonably forseeable activities.

In addition to the proposed SNF management facilities, reasonably foreseeable activities considered in this cumulative impact assessment include the proposed Expended Core Facility (described in Volume 1, Appendix D), activities included in the present Five-Year Plan and Master Plan for the NTS (DOE/NV 1993b), and the potential geologic repository at the Yucca Mountain site. Major programmatic initiatives consist of constructing the following: facilities and site improvements for a new consolidated testing area sponsored by Los Alamos and Lawrence Livermore National Laboratories; a Transuranic Waste Certification Building; refurbishment or expansion of several existing facilities; construction of several small office buildings; several site assessment and remediation projects; several roadway upgrading or improvement projects; several flood control projects; and several utility installation or upgrade projects. In addition, a

number of communications, security, an safety improvements identified in the Master Plan are under consideration throughout the NTS.

Specifically with respect to Area 5, a number of projects are proposed (DOE/NV 1993b). Continued use of the Radioactive Waste Management Site and the Spill Test Facility is proposed. Providing storage for transuranic waste and hazardous waste prior to offsite disposal is also proposed. Additional projects have also been proposed to provide utility and infrastructure upgrades and improvements. These projects include replacing the Frenchman Flat power substation and a number of construction projects for water Service Area C including connecting the Yucca Flat and Frenchman Flat water systems, and adding additional tanks and water lines in the area. Nearby proposals identified for Area 6 include following a formal, expansion-oriented land-use plan for the Control Point, Yucca Lake, and the Construction Facilities.

The potential geologic repository at the Yucca Mountain site, which could involve construction and operation of a geologic repository for spent nuclear fuel and high-level waste on NTS land and other federal land on the western boundary of the NTS, is also considered in this cumulative impacts analysis. Considering the relatively isolated location of the NTS, future new offsite activities (other than the potential geologic repository at Yucca Mountain) are assumed to be of limited scope.

The following cumulative impacts analysis considers the potential incremental effects from the proposed SNF management facilities and the proposed Expended Core Facility in detail. The potential incremental impacts from activities proposed in the Five-Year Plan, and Master Plan the potential geologic repository at the Yucca Mountain site, and from future offsite activities are assessed in a more qualitative manner.

5.16.1 Centralization Alternative

Separate analyses of potential cumulative impacts from the Centralization Alternative against the environmental baseline conditions presented in Chapter 4 are provided below.

5.16.1.1 *Land Use.* Construction of the proposed SNF management facilities would require the dedication of approximately 90 acres (0.36 square kilometer) of undeveloped land on the NTS. Construction of the proposed Expended Core Facility would require the dedication of an additional 30 acres (0.12 square kilometer) of undeveloped land, increasing the total land requirement to 120 acres (0.48 square kilometer). This represents less than 1 percent of the roughly 450,000 acres (1,800 square kilometers) of undeveloped land remaining on the 864,000 acre (3,500 square kilometers) NTS. Additional unknown areas of undeveloped land, generally parcels of under 100 acres (0.4 square kilometer), might have to be dedicated to some of the activities proposed in the Five-Year Plan and Master Plan. Many of these proposed activities do not require the dedication of undeveloped land. Land on the southwestern part of the NTS has already been allocated for the potential Yucca Mountain repository and current site characterization for a potential geologic repository at the Yucca Mountain site.

Considering the large area of undeveloped land on the NTS, the cumulative dedication of land to all reasonably foreseeable activities on NTS would not likely serve to further limit the availability of land on the NTS for future development. Large areas of undeveloped land are available for development off of the NTS, and any future offsite development coupled with the proposed onsite development discussed above is not likely to create regional land shortages that could severely limit future regional development.

5.16.1.2 *Occupational and Public Health.* The annual collective effective dose equivalent from the existing NTS facilities to the population within 50 miles (80 kilometers) of the NTS is 0.0052 person-rem. Added to this baseline, operation of the proposed SNF management facilities might contribute an additional 0.082 person-rem, increasing the cumulative effective dose to 0.087 person-rem.

The annual collective effective dose equivalent from the existing NTS facilities to a potential maximally exposed individual at the site boundary is 0.011 millirem per year. Operation of the proposed SNF management facilities might contribute an additional 0.12 millirem per year, resulting in a cumulative annual dose of 0.13 millirem per year to this maximally exposed individual.

The total annual baseline worker dose seen from normal NTS operations is about 4 person-rem. The total annual SNF management facility worker dose is expected to be roughly 32 person-rem. Hence, the cumulative annual dose might be 36 person-rem.

Over the planned 40-year operational lifetime of the SNF management facility, a total population dose of 3.5 person-rem will be observed from continuous operation of the existing NTS facilities and the SNF management facility. This equates to a risk of fatal cancer of 4.4×10^{-5} over the 40-year span. For the maximally exposed individual, the total dose over the 40-year period equates to a risk of fatal cancer of 2.6×10^{-6}. For the SNF management worker, the total dose over the 40-year span corresponds to a risk of fatal cancer of 6.4×10^{-4}.

Additional radiological impacts are not expected from operation of the proposed Expended Core Facility. Analysis has shown that the dose to all individuals considered (workers, and offsite individuals) from Expended Core Facility operations might be much less than one millirem per year.

5.16.1.3 *Noise.* Increases in noise levels from construction and operation of the SNF management facilities and the Expended Core Facility would be limited to temporary, minor construction noise and small increases in traffic noise occurring along various access routes to the NTS due to increases in employment. Because of the NTS's large size and sparsely inhabited surroundings, any cumulative noise levels generated on the NTS by the proposed SNF management facilities, the proposed Expended Core Facility, the potential geologic repository at the Yucca Mountain site, and activities proposed in the Five-Year Plan and Master Plan would not propagate offsite at levels that would impact the general population. Although the cumulative offsite noise level attributed to future offsite activities can not be estimated, the potential incremental addition attributable to the proposed SNF management facilities would be minimal. Minor increases in traffic noise on U.S. Route 95 could be possible due to increases in activity on and near the NTS.

5.16.1.4 *Groundwater and Surface Water Resources.* Operation of the proposed SNF management facilities would require the withdrawal of an estimated 3.6 million gallons per year (13.6 million liters per year) of groundwater from the Ash Meadows Subbasin. Operation of the proposed Expended Core Facility would require the withdrawal of an estimated additional 2.5 million gallons per year (9.5 million liters per year) from that subbasin, resulting in a combined withdrawal of an estimated 6.1 million gallons per year (23.1 million liters per year). The water demands for the potential geologic repository at the Yucca Mountain site would be met by the Alkali Flat Furnace Creek Ranch Subbasin and therefore would not contribute to the cumulative water withdrawals from the Ash Meadows Subbasin. Information concerning the water demands of activities in the Five-Year Plan, Master Plan, or future offsite activities is not available.

Although total withdrawals of groundwater from the Ash Meadows Subbasin have not exceeded the subbasin perennial yield, localized withdrawals of groundwater in the Frenchman Flat hydrographic area of the Ash Meadows Subbasin have exceeded the estimate of precipitation recharge for the area. This recharge estimate was exceeded for more than thirty years with no decline in static water levels. Accurate measurement of static water levels are, however, precluded by numerous conditions on the NTS. Because of hydrogeologic complexities, regional groundwater flow at the NTS is not constrained by the hydrographic basins which are defined by local topography. Therefore any potential groundwater overdraft in the Frenchman Flat hydrographic area indicated by previous yield estimates are likely be made up by untapped groundwater from neighboring hydrographic basins. Localized impacts could occur if the perennial yield of Frenchman Flat hydrographic area is exceeded. Potential impacts include depletion of water stored locally in the regional aquifer, removal of that groundwater from other potential uses, and the potential modification of the rate and direction of contaminant migration resulting from underground nuclear testing. The complex issues of groundwater contamination and use are being addressed in the Resource Management Plan being prepared in conjunction with the NTS site-wide EIS.

5.16.1.5 Biotic Resources. Construction of the proposed SNF management facilities would require the disturbance of approximately 90 acres (0.36 square kilometer) of desert habitat supporting flora and fauna characteristic of the ecotone between the Mohave Desert and the Great Basin. Construction of the proposed Expended Core Facility would require the disturbance of an additional 30 acres (0.12 square kilometer) of desert habitat, resulting in a combined conversion of 120 acres (0.48 square kilometer) of terrestrial habitat to developed uses.

Additional areas of desert habitat would be lost during construction of activities proposed in the Five-Year Plan and Master Plan, during construction of the potential geologic repository at the Yucca Mountain site, and during future offsite construction activities. Considering the broad extent of desert habitat on and surrounding the NTS, the cumulative loss of desert habitat would be minimal.

The NTS lies within the range of the desert tortoise, a federally listed threatened species. If the desert tortoise occurred in areas subject to development, tortoises could be injured from construction activities. The proposed SNF management facilities (and the proposed Expended Core Facility) would be constructed at the edge of the tortoise's range, however, and few have been found in the affected area. Habitat losses due to construction of the proposed SNF management facilities and other proposed onsite and offsite construction activities could result in a slight cumulative loss of habitat for the desert tortoise. The U.S. Fish and Wildlife Service would be consulted in accordance with Section 7 of the Endangered Species Act prior to construction of the potential SNF management facilities to ensure that any potential cumulative effect on desert tortoise populations would be minimal. The U.S. Fish and Wildlife Service would also have to be similarly notified and given an opportunity to comment prior to construction of the potential geologic repository at the Yucca Mountain site and prior to any other major construction activities.

5.16.1.6 Air Quality. The potential cumulative air emissions from the proposed SNF management facilities and the proposed Expended Core Facility would not result in an exceedance of the National Ambient Air Quality Standards or Nevada state criteria. Also, there would be no exceedance of Federal National Emissions Standards for Hazardous Air Pollutants or DOE radiological standards. Air emissions from the other planned activities have not yet been defined.

5.16.1.7 Socioeconomics. Operation of the proposed SNF management facilities might generate up to 800 new jobs during the year 2005 and beyond. Operation of the proposed Expended Core Facility might generate up to 562 additional jobs during that year, resulting in a combined increase of up to 1,362 new jobs. The 7,091 jobs presently forecasted for the NTS in the year 2005 might be increased by 19 percent, to as much as 8,453 jobs. The 752,356 jobs presently forecasted for the surrounding area in the year 2005 might be increased by less than 1 percent, to as much as 753,718 jobs. Additional employment increases could also result from the potential geologic repository at the Yucca Mountain site, activities proposed in the Five-Year Plan and Master Plan, and new offsite activities, but specific estimates are not available.

The cumulative effect of the employment increases discussed above would depend on future actions at the NTS and throughout the regional economy. These employment increases could cause minor fluctuations in employment and housing demands. However, activities at the NTS generally have a relatively modest effect on long-term regional economic growth and productivity in Clark County because of the implicit growth projections in the services and retail trade sectors driving long-term growth in the Las Vegas Metropolitan Statistical Area. Additionally, in recent years the shutdown of nuclear testing activities at the NTS has caused employment levels to fall. These losses have not been considered in long-term employment forecasts. If nuclear testing activities do not resume at the NTS, the projected employment increases noted above could be offset by employment losses.

5.16.1.8 Transportation. An estimated 4.0 x 10^{-4} and 1.4 x 10^{-3} accident occupational fatalities and accident nonoccupational fatalities might occur over the 40-year life of the proposed SNF management facilities due to the transportation of hazardous material to the facilities. This does not include fatalities due to leakage of hazardous waste. Similar data are not available for the other planned activities.

5.16.1.9 Waste Management. Operation of the proposed SNF management facilities would generate an estimated 203 cubic meters (266 cubic yards) per year of low level waste and an estimated 16 cubic meters (21 cubic yards) per year of transuranic waste. Operation of the proposed Expended Core Facility would generate an additional 425 cubic meters (556 cubic yards) of low level waste (for a combined total by both facilities of 628 cubic meters (821 cubic yards)) but would not generate any additional transuranic waste. No other radioactive waste, including high level waste or mixed waste, would be generated by either facility. Comparable data for the potential geologic repository at the Yucca Mountain site or for offsite activities or activities proposed in the Five-Year Plan and Master Plan is not available. All wastes generated

by the proposed SNF management facilities and other planned activities on the NTS would be treated and disposed of in accordance with all applicable Federal and state regulations.

5.16.1.10 Other Resources. The absence of impacts, or very minimal impacts, from the proposed SNF management facilities to cultural resources, aesthetic and scenic resources, utilities, and geologic resources ensures that their potential contribution to cumulative impacts affecting these resources would be negligible.

5.16.2 Regionalization Alternative

Because impacts from the proposed SNF management facilities under the Regionalization Alternative would be equal to or less than those under the Centralization Alternative, the potential cumulative impacts would also be equal or less. Generally, the Regionalization Alternative requires less construction and smaller scale operations, and the potential for cumulative impacts is therefore less.

5.17 Adverse Environmental Effects That Cannot Be Avoided

5.17.1 Overview

This chapter discusses potentially unavoidable adverse impacts to the environment resulting from construction and operation of the proposed SNF facilities at the NTS under the Centralization and Regionalization Alternatives. Unavoidable adverse impacts are impacts which cannot be mitigated by changes in project design, operation, or construction, or by other measures.

5.17.2 Centralization Alternative

Operation of the proposed SNF facilities at the NTS under the Centralization Alternative would increase the radiation dose rate to the maximally exposed individual by 0.12 millirem/year, resulting in only a minimal increase in cancer risk. The number of fatal cancers per year of operations on the NTS from existing sources and the SNF facilities would be 4.4 x 10^{-5}.

Construction of the proposed SNF facilities would require the disturbance of approximately 90 acres (0.36 square kilometer) of undeveloped land. Although this represents less than 1 percent of the undeveloped land on NTS, it would eliminate potential terrestrial wildlife habitat, including habitat potentially suitable for the federally listed desert tortoise. It would also require the dedication of a small land parcel potentially suitable for other construction projects, but similar land parcels are abundant on the NTS.

Operation of the proposed SNF facilities would require the withdrawal of an estimated 3.6 million gallons (13.6 million liters) per year of groundwater from the Ash Meadows Subbasin. Existing localized withdrawals of groundwater from Frenchman Flat hydrographic area of this subbasin already exceed the estimate of precipitation rechange for the area. However, the total withdrawal from the Ash Meadows Subbasin does not exceed its total perennial yield. Any water withdrawn would therefore not be discharged at Ash Meadows and the other discharge points in the deserts southwest of NTS.

The potential impacts from the Centralization Alternative to the other environmental resources discussed in Chapter 5 are not unavoidable adverse impacts.

5.17.3 Regionalization Alternative

Potential unavoidable adverse impacts associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. The extent of the impacts could be less due to the reduced land requirements, reduced extent of construction disturbance, and reduced scale of operations.

5.18 Relationship Between Short-Term Use of the Environment and the Maintenance and Enhancement of Long-Term Productivity

Implementation of any of the SNF management alternatives would cause some adverse impacts to the environment and permanently commit certain resources. These resources include use of the environment and those associated with construction and operation of the SNF management facilities.

The proposed alternatives for SNF management would require the short-term use of resources including energy, construction materials, and labor in order to achieve the objective of safety managing SNF to minimize the risk to workers, the public, and the environment.

Development of new SNF interim management facilities would commit lands to those uses from the time of construction through the cessation of operations, at which time the facilities could be converted to other uses or decontaminated, decommissioned, and the site restored to its original land use.

5.19 Irreversible and Irretrievable Commitments of Resources

5.19.1 Overview

This chapter discusses the irreversible and irretrievable commitments of resources resulting from the use of materials that can not be recovered or recycled, or that must be consumed or reduced to irrecoverable forms.

5.19.2 Centralization Alternative

Construction and operation of SNF facilities under the Centralization Alternative would require commitments of electrical energy, fuel, concrete, steel, sand, gravel and miscellaneous chemicals. Groundwater to operate the SNF facilities would not be discharged in the deserts to the southwest of NTS. More detailed analyses would be required to determine irreversible effects on localized groundwater availability. The land dedicated to the SNF facilities would become available for other rural uses following closure and decommissioning.

5.19.3 Regionalization Alternative

Irreversible and irretrievable commitments of resources associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. However, the extent of these resource commitments could be less, due to the reduced land requirements and reduced scale of operations.

5.20 Potential Mitigation Measures

5.20.1 Pollution Prevention

The DOE Nevada Field Office (DOE/NV) published a Waste Minimization and Pollution Prevention Awareness Plan in June 1991 to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at DOE/NV facilities. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All DOE/NV contractors and NTS users that exceed the EPA criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs that are implemented by the DOE/NV plan. Contractor programs ensure that waste minimization activities are in accordance with Federal, state, and local environmental laws and regulations, and DOE Orders (DOE/NV 1993c).

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of wastes generated, and implementation of recycling programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor and NTS user has been established to coordinate DOE/NV waste minimization and pollution awareness activities (DOE/NV 1993c).

5.20.2 Potential Mitigation Measures

Potential impact avoidance and mitigation measures are addressed in Chapter 5, Sections 1 through 15 as appropriate.

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7.0 ABBREVIATIONS AND ACRONYMS

°C	degrees Celsius
CFR	Code of Federal Regulations
Ci	curie(s)
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EIS	environmental impact statement
ECF	Expended Core Facility
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
g	gram
gal	gallon(s)
hr	hour
INEL	Idaho National Engineering Laboratory
kg	kilogram
km	kilometer
kv	kilovolt
ℓ	liter
m	meter
m^3	cubic meter
mi	mile
mi^2	square mile
min	minute
mph	miles per hour
mR	milliroentgen
mrem	millirem
MTHM	metric tons of heavy metal
MW	Megawatt
nCi	nanocurie
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission

NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
pCi	picocurie(s)
PEIS	Programmatic Environmental Impact Statement
PM^{10}	particulate matter less than 10 microns in diameter
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
SNF	spent nuclear fuel
SRS	Savannah River Site
TVA	Tennessee Valley Authority
μg	micrograms
USGS	U.S. Geological Survey
yr	year

OAK RIDGE RESERVATION

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1. INTRODUCTION

This part assesses the impacts of construction and operation of proposed spent nuclear fuel (SNF) facilities at the Oak Ridge Reservation (ORR). The ORR is being evaluated for these facilities because of the area available, the apparently suitable site environmental parameters, previous U.S. Department of Energy activities involving radioactive materials at the site and the planned long-term government control of the site.

This appendix is organized as follows. Chapter 1 is the introduction, Chapter 2 sets the stage for the area under analysis by providing an overview of the ORR and a discussion of the Regulatory Framework and the SNF Management Program, and Chapter 3 explains the SNF alternatives being considered at the site.

Chapter 4 describes the human and natural environment that could be affected as a result of the introduction of an SNF facility at the ORR. Environmental parameters such as water resources, socioeconomics, biological resources, and air quality are examples of those characterized.

Chapter 5 enumerates the environmental consequences that might be anticipated, summarizes the cumulative impacts, describes unavoidable adverse impacts, and describes the irreversible and irretrievable commitment of resources that might be anticipated if an SNF facility were built at the ORR. Chapter 6 contains the references used to develop this part of the environmental impact statement. Chapter 7 contains a list of abbreviations and acronyms used in this part of the environmental impact statement.

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2. OAK RIDGE RESERVATION SITE BACKGROUND

2.1 Overview

2.1.1 Site Description

The Oak Ridge Reservation (ORR) is located on approximately 34,667 acres (140 square kilometers) of federally owned land within the incorporated city limits of Oak Ridge, Tennessee (see Figure 2.1-1). The City of Oak Ridge and the ORR lie between the Cumberland and Southern Appalachian mountain ranges. Knoxville is located approximately 25 miles (40 kilometers) southeast of the ORR and is the largest city in the area. The population varies within the five counties surrounding the ORR. The area around Knoxville is a heavily populated and highly developed urban area, whereas the area surrounding the ORR is sparsely populated, with the exception of the city of Oak Ridge, which is considered to have medium density population. The two main land uses in the five counties surrounding the ORR are forestry and agriculture.

Within the ORR there are three primary complexes: the Y-12 Plant, the K-25 Site (formerly the Oak Ridge Gaseous Diffusion Plant), and the Oak Ridge National Laboratory (ORNL) (see Figure 2.1-2). Currently these facilities are being used for research, development, and production.

The Y-12 Plant is located on the eastern portion of the ORR known as Bear Creek Valley. The Y-12 Plant serves as a key manufacturing technology center for the development and demonstration of unique materials, components, and services of importance to DOE and the nation. This mission is accomplished through the reclamation and storage of nuclear materials, the manufacture of components to the nation's defense capabilities, support to national security programs, and services provided to other customers as approved by DOE (MMES 1994a).

The K-25 Site is located on the northwestern portion of the ORR. Its mission is to provide a base of operation for the Energy Systems Environmental Restoration and Waste Management programs, thus serving as the "platform" for the restoration of the environment and management of DOE wastes through leadership and central management of the Environmental Restoration

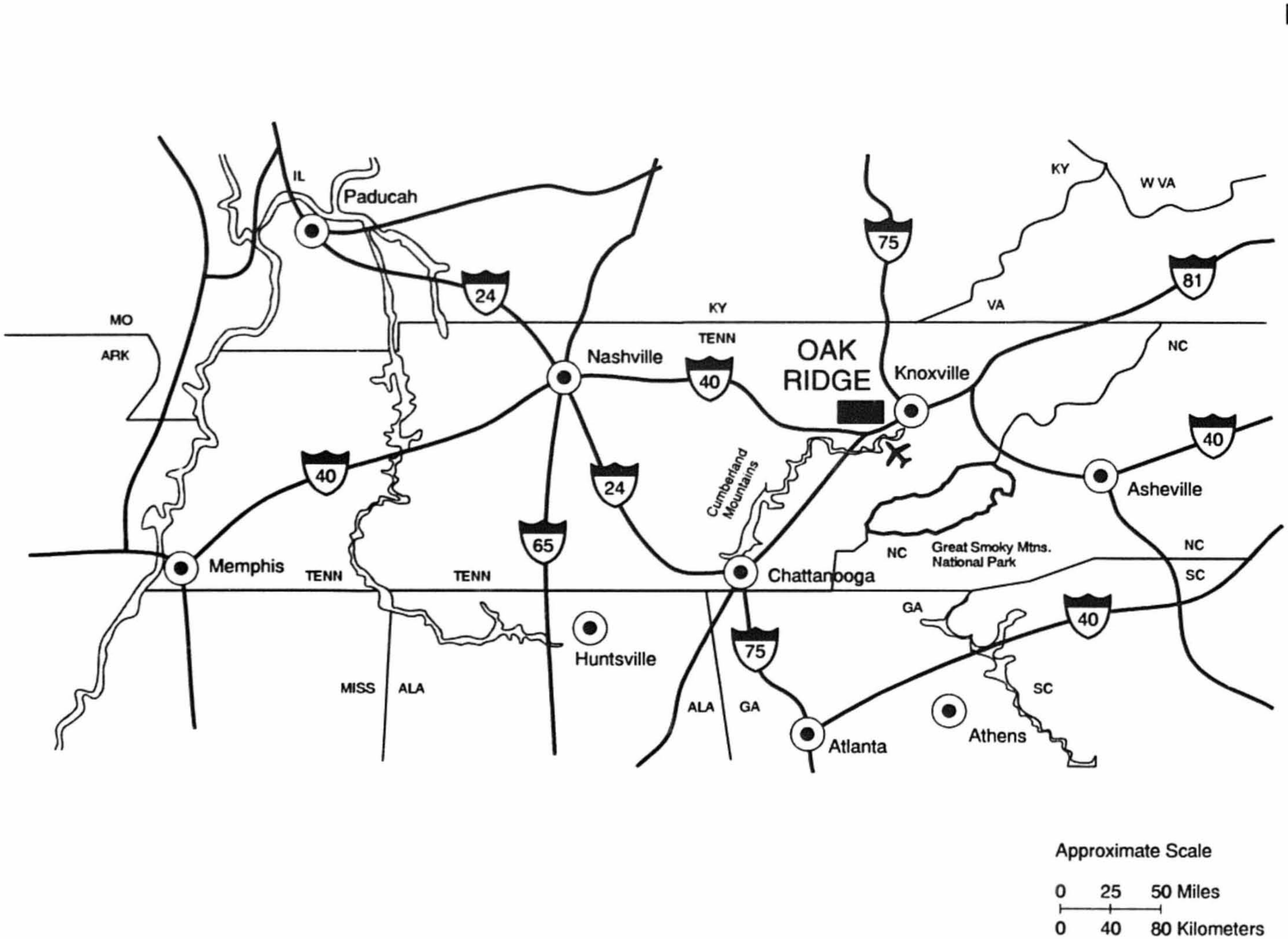
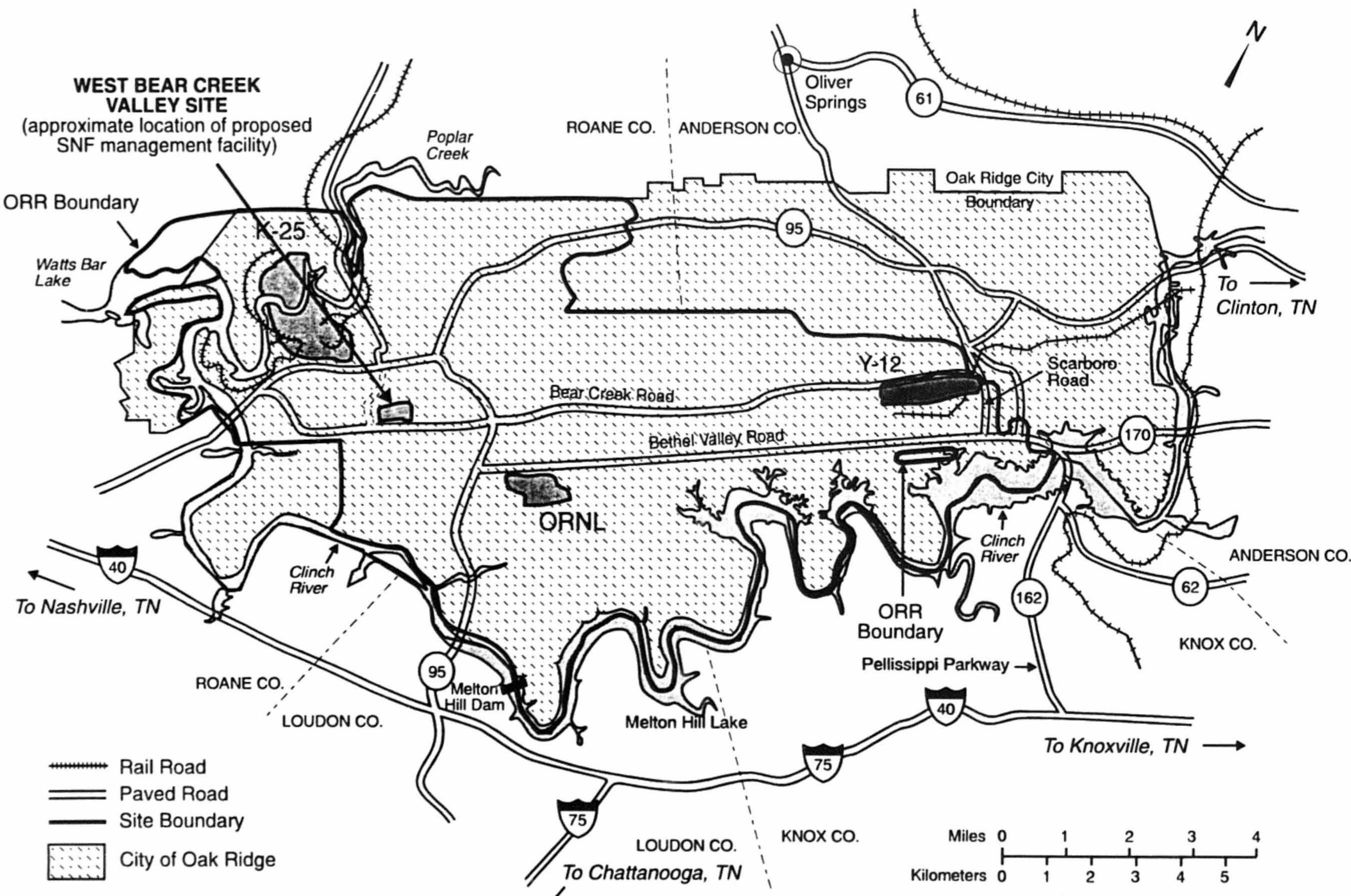


Figure 2.1-1. Oak Ridge Reservation regional map.



Source: MMES 1994a.

Figure 2.1-2. Oak Ridge Reservation site and transportation.

and Waste Management and Technology Development Programs in support of DOE, sites managed for DOE by Energy Systems, other elements of the Federal Government, and the public. The Toxic Substances Control Act incinerator is managed by and located on the K-25 Site (MMES 1994a).

The ORNL is located in the southern portion of the ORR. The primary mission of ORNL is to perform leading edge research and development in support of nonweapons roles of DOE (MMES 1994a). The ORNL uses test and experimental reactors to perform research and for small-scale radioisotope production activities. The amount of spent nuclear fuel (SNF) generated by these facilities, the amount expected to be generated through the year 2035, and accommodations being undertaken at the present time to store the fuel currently being generated are discussed in the following sections.

The buildings located off the ORR but owned and/or operated by the U.S. Department of Energy (DOE) are 1) the Scarboro Facility, 2) the Central Training Facility, 3) the Transportation Safeguards Division Maintenance Facility, and 4) some ancillary and administrative facilities and structures. The majority of the facilities used by various plant protection and security groups are located within the plant's boundary. Other offsite facilities include the DOE Oak Ridge Operations Office, the DOE Office of Scientific and Technical Information, the Oak Ridge Associated Universities facilities, the American Museum of Science and Energy, the prime contractor's "Townsite" facilities, the National Oceanic and Atmospheric Administration's Atmospheric Turbulence and Diffusion Laboratory, and others. With the exception of the Federal Office Building and space leased from the private sector, all facilities are located on DOE-owned land.

The proposed site of the SNF management facility is located on 100 acres (0.40 square kilometer) of land designated as the West Bear Creek Valley site (see Figure 2.1-2) (La Grone 1994; MMES 1994b). The proposed SNF storage facility will require 90 of the 100 acres (0.36 of the 0.40 square kilometer) set aside for the facility (Johnson, V. 1994).

The proposed SNF management facility is on Bear Creek Road adjacent to the Clinch River on the west end of the ORR. The westernmost boundary of the proposed SNF facility is

less than 1 mile (1.6 kilometers) from the ORR boundary. Across Bear Creek Road from the proposed SNF management facility there is a privately owned industrial park (MMES 1994b).

2.1.2 Site History

The ORR was originally purchased in the early 1940s to house the large-scale production of fissionable material for the first nuclear weapon in the world. The original tract of land purchased was 56,833 acres (230 square kilometers). Portions of the original tract were used to build the City of Oak Ridge for the people who constructed and operated the ORR. Residential and business areas of the city were sold, and the ORR has been reduced to its present size.

ORNL began in 1943 as the Clinton Laboratories, a pilot plant for testing and development of the plutonium-239 production and chemical separations processes. Major facilities at the ORNL included the X-10 Graphite Reactor, a chemical pilot plant, and numerous support laboratories and shops. The ORNL's initial mission was fulfilled by 1945, but because of its unique capabilities, new research and development programs were initiated in energy, materials, and environmental technology (DOE 1988).

Since 1945 emphasis at ORNL has been on exploration of the use of nuclear science and technology, which continues as a major component of research and development of the laboratory. A number of additional nuclear reactors and supporting facilities have been built and operated at ORNL since the original mission associated with the Manhattan Project. Research and development in nuclear science and technology is supported currently by one operating research reactor, the High Flux Isotope Reactor. ORNL has proposed the Advanced Neutron Source, which would take over many of the tasks now carried out by the High Flux Isotope Reactor (Brown 1994a; Hoel 1994).

In 1943 the Y-12 Plant was constructed as part of the Manhattan Project. The Y-12 Plant separated fissionable isotopes of uranium-235 by the electromagnetic process, which was used in the world's first atomic bomb, detonated on August 5, 1945 (MMES 1990; DOE 1987). Since that time Y-12 has developed into a highly sophisticated nuclear weapons component manufacturing and development engineering organization and currently is used for weapons disassembly.

The Oak Ridge Gaseous Diffusion Plant, now the K-25 Site, was used to produce enriched uranium for U.S. nuclear weapons. It also provided an industrial toll enrichment service, in which uranium was enriched for use in nuclear-powered reactors around the world. In 1987, the Oak Ridge Gaseous Diffusion Plant was permanently shut down.

2.1.3 Mission

The missions of the primary plant complexes within ORR are:

- Energy Research and Development at ORNL.

- Reclamation and Storage of Nuclear Material, Manufacturing of Defense Hardware, and National Security, Technology Transfer, and Work for Others Programs at Y-12.

- Environmental Restoration and Waste Management at the K-25 Site (MMES 1994a).

The mission of ORNL includes services that only research reactors provide, including, 1) the production of transuranium isotopes used in basic research, medical, defense, and industrial applications, 2) neutron scattering research to determine fundamental structure and properties of materials, 3) production of unique isotopes for medical treatment and research, 4) production of special commercial isotopes, and 5) irradiation of structural and fuel materials for fusion energy reactors and advanced nuclear reactors (Brown 1994a; Hoel 1994).

2.1.4 Oak Ridge Reservation Operations Management

Martin Marietta Energy Systems, Inc., operates the major facilities at the ORR (Y-12 Plant, K-25 Site, and ORNL). They are under contract to and administered by the DOE Oak Ridge Operations Office. Current missions and functions can be grouped into the following four

categories: defense production activities; environmental management activities; other DOE activities; and work for others.

2.2 Regulatory Framework

The National Environmental Policy Act (NEPA) of 1969 (42 USC 4321-4347, as amended) provides Federal agency decision makers with a process to systematically consider the potential environmental consequences of agency decisions. The DOE has prepared this environmental impact statement (EIS) in conformance with the requirements of NEPA to evaluate the potential impacts of programmatic decisions on the management of SNF. This EIS provides the necessary background, data, and analyses to help decision makers understand the potential environmental consequences of each alternative.

On October 22, 1990, the DOE published a Notice of Intent in the *Federal Register* (FR 1990) announcing its intent to prepare a programmatic EIS addressing environmental restoration and waste management (including SNF management) activities across the entire DOE complex. On October 5, 1992, the DOE published a Notice of Intent in the *Federal Register* (FR 1992) announcing its intent to prepare an EIS addressing environmental restoration and waste management and SNF activities at the Idaho National Engineering Laboratory. For further programmatic discussion of this topic, see Volume 1.

Significant state environmental and nuclear materials management laws applicable to the ORR include the following (listed alphabetically):

- Air Pollution Control Regulations (Chapter 1200-3)

- Air Quality Act (Title 68 Chapter 201-101)

- Emergency Rules--Hazardous Substance Remedial Action (Chapter 1200-1-13)

- Emission Standards and Monitoring Requirements for Additional Control Areas (Chapter 1200-3-19)

- Hazardous Substance Site Remedial Action (Chapter 1200-1-13)
- Hazardous Waste Management (Chapter 1200-1-11)
- Licensing Requirements for Land Disposal of Radioactive Waste (Chapter 1200-2-11)
- New Source Performance Standards (Chapter 1200-3-16)
- Prevention of Hazards and Pollution (Chapter 1200-1-6)
- Rules and Regulations Applied to Tennessee Codes Annotated §69-1-1 (Chapter 1200-4-8)
- Solid Waste Processing and Disposal (Chapter 1200-1-7)
- Underground Storage Tank Program (Chapter 1200-1-15)
- Visible Emission Regulations (Chapter 1200-3-5)
- Volatile Organic Compound (Chapter 1200-3-18)

2.3 Spent Nuclear Fuel Management Program

In the past, reactor-irradiated nuclear materials, which include SNF and reactor-irradiated target material, have been stored prior to reprocessing activities to recover plutonium, tritium, and other isotopes. In the past several years, however, the DOE has either phased out or stopped its reprocessing of these materials. With this change, reactor-irradiated nuclear materials were being stored for longer periods of time than originally planned. The amount of reactor-irradiated nuclear materials and the conditions of storage for the materials were in question throughout DOE facilities.

In an effort to assess whether extended storage conditions for reactor-irradiated nuclear materials are safe (i.e., whether protection exists for workers, the public, and the environment), the DOE commissioned a study. This assessment also grouped any vulnerabilities of the storage conditions into three categories where management attention could be directed: less than 1 year, 1 to 5 years, and greater than 5 years. In November 1993, the DOE published the *Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and other Reactor Irradiated Nuclear Materials and Their Environmental, Safety and Health Vulnerabilities*, hereafter referred to as the *Spent Fuel Working Group Report*, as a result of the assessment efforts (DOE 1993b; 1994b).

As a result of the *Spent Fuel Working Group Report*, a *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities* was also commissioned to address what was discovered in the original Working Group Report. Phase I of the *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities* was published in February 1994. Phase II and Phase III were issued April 1994 and October 1994, respectively. To address the vulnerabilities identified in the *Spent Fuel Working Group Report*, individual action plans were developed to reflect the DOE's sense of urgency, concern for worker protection, commitment to minimize environmental impacts, and need for compatible long-term solutions.

The ORR was assessed as part of the *Spent Fuel Working Group Report*. SNF located on the ORR is currently stored in facilities at the ORNL. The SNF at ORR is primarily spent fuel from research or experimental reactors that are operating or have operated at ORNL. Samples of SNF left over from research on fuel elements removed from commercial or demonstration reactors utilized by DOE predecessor agencies for advancement of nuclear science are also present. In the past, most of the SNF from the Oak Ridge research and experimental reactors was chemically processed to recover fissile materials at Savannah River Site (Brown, 1994a; Hoel 1994).

This section describes the status of the SNF at the ORR using the information presented in the *Spent Fuel Working Group Report*, the *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities*, the *Spent Fuel Inventory Data* developed for the SNF EIS, and through discussions with ORR. If fuel can be contact handled, it has not been listed in the Spent Fuel Inventory as

SNF. The SNF management program at ORR utilizes 10 facilities for storage. These facilities and their SNF contents are summarized on Table 2.3-1.

2.3.1 Building 3525 - Irradiated Fuels Examination Laboratory

This two-story brick structure was built in 1963 and contains hot cells. The facility mission continues to be disassembly and examination of irradiated fuel and components. Building 3525 contains 1 unit of research reactor fuel in the form of fuel samples and targets (DOE 1993b; Wichmann 1995a, b).

2.3.2 Building 4501 - High-Level Radiochemical Laboratory

Constructed in 1951, this facility contains centrally located hot cells supported by various laboratories capable of handling radioactive materials. SNF is in dry storage at this facility. Building 4501 contains 0.006 metric tons of heavy metal (MTHM) of DOE-owned commercial fuel (DOE 1993b; Wichmann 1995a, b).

2.3.3 Building 7920 - Radiochemical Engineering Development Center

The Radiochemical Engineering Development Center is a multipurpose hot cell facility with equipment, shielding, and containment provisions to safely process and store significant quantities of highly radioactive targets. This facility was specifically built to prepare and process targets from the High Flux Isotope Reactor. Building 7920 contains 0.024 MTHM of research reactor fuel in the form of fuel samples in dry storage (DOE 1993b; Wichmann 1995a, b).

2.3.4 Dry Storage Facilities 7823A, 7827, and 7829

Now closed to further storage, these shielded, retrievable storage facilities are stainless-steel dry wells placed in the ground in Solid Waste Storage Area 5 North. They vary from 8 to 30 inches (20 to 76 centimeters) in diameter and from 10 to 15 feet (3 to 4.6 meters) in depth. The wells are placed on a concrete pad and are held in place by concrete collars or slabs and are surrounded by dirt. Spent fuel and other materials were placed in the wells beginning in 1972.

Table 2.3-1. Oak Ridge Reservation SNF Storage Facilities.

Facility name	Material stored at facility	Heavy metal mass (MTHM)
High Flux Isotope Reactor (HFIR) Pool	HFIR fuel	0.45
Bulk Shielding Reactor (BSR) Pool	BSR & ORR fuel	0.01
Molten Salt Reactor Experiment (MSRE)	MSRE fuel	0.037
Bldg. 4501	Misc. LWR fuels	0.006
Tower Shielding Reactor (TSR)	TSR fuel	0.0092
Facility 7823A	Misc. fuel	0.0008
Facility 7827	Misc. fuel	0.0837
Facility 7829	Peach Bottom	0.0137
Bldg. 7920	Dresden-1 fuels	0.024
Bldg. 3525	Misc. fuels	
Solid Waste Storage Area 6	KEMA Suspension Test Reactor fuel[a]	0.037

Source: Wichmann (1995a,b)

a. See Section 2.3.5.6.

Facility 7823A contain 0.0008 MTHM; facility 7827 contains 0.0837 MTHM; and facility 7829 contains 0.0137 MTHM. Activities to address the vulnerabilities in these facilities include 1) transferring the fuel, 2) adding a new inner liner and relocating fuel in modified units, and 3) overpacking any fuel in suspect condition. These activities are expected to be completed in fiscal year 1996 (DOE 1994b; 1993b; Wichmann 1995a, b).

2.3.5 Research Reactors

Six existing reactors and one planned reactor are expected to be generating and storing SNF at the ORNL. They are the High Flux Isotope Reactor (currently operating), the Tower Shielding Reactor No. II (shut down in 1992), the Bulk Shielding Reactor (shut down in 1991), the Oak Ridge Research Reactor (shut down in 1987), the Molten Salt Reactor Experiment (shut down in 1969), the KEMA Suspension Test Reactor, and the Advanced Neutron Source Reactor (planned to start up in 2002 or 2003) (ANS 1988).

2.3.5.1 High Flux Isotope Reactor. The High Flux Isotope Reactor is a beryllium-reflected, light water cooled and moderated, flux-trap-type reactor. The reactor uses aluminum-clad fuel plates containing highly enriched uranium-235. The reactor became operational in 1965 and its current power level is 85 megawatts. Reactor missions include production of isotopes for medical and industrial applications, neutron-scattering experiments, and various material irradiation experiments (ANS 1988; DOE 1993b).

The High Flux Isotope Reactor is operating. At the present time there are 62 fuel assemblies amounting to 0.45 MTHM from the research reactor fuel in onsite wet storage. The High Flux Isotope Reactor currently does not use onsite dry storage. If the reactor continues operation through the year 2035, the predicted SNF production will be an additional 110 fuel assemblies totalling 1.58 MTHM. (Holt 1993; ORNL 1992a; Wichmann 1995a, b).

Onsite storage at the reactor facility would have to be expanded to accommodate this projected SNF generation rate. At the present time, reracking the existing storage facility and installing modular dry-storage units at the High Flux Isotope Reactor are being considered. With

the installation of the dry-storage units, the potential for future expansion of storage facilities is expected to continue indefinitely (ORNL 1992a).

In the past, SNF assemblies were shipped in casks via truck to the Savannah River Site, and the baseline plan is to continue shipments there. However, the Savannah River Site has limited space and plans to accept only 20 fuel assembly shipments from the High Flux Isotope Reactor. If shipment of SNF to another DOE storage facility is precluded or the commencement of reracking at the High Flux Isotope Reactor is not approved by the DOE, the reactor will be required to shut down because the present pool storage racks cannot accommodate additional fuel after early 1995 (Clark 1994).

2.3.5.2 Tower Shielding Reactor No. II and Tower Shielding Facility Building 7708. The 1 megawatt Tower Shielding Reactor No. II is a light water moderated, movable tank, research reactor which was shut down in 1992. There are no plans for resuming operations at this time. Tower Shielding Reactor No. II has no containment and was used at ground level or suspended from towers. The research included testing shielding designs and obtaining associated data (ANS 1988; DOE 1993b).

The Tower Shielding Reactor No. II was placed in standby in September 1992 pending DOE direction to prepare the facility for shutdown. At that time, the only existing Tower Shielding Reactor No. II fuel assembly was being stored in the reactor core. For handling and storage purposes, an element is an integral core assembly composed of 4 upper central plates, 4 lower central plates, 12 annular plates, a central plug, and 4 fuel plates. One element, 0.0092 MTHM, is being stored in the reactor core. The corrective actions associated with the vulnerabilities identified in the *Spent Fuel Working Group Report* for the Tower Shielding Reactor No. II and Tower Shielding Facility Building 7708 are: 1) implement access control to the Tower Shielding Reactor No. II area; 2) implement emergency operating procedures for the Tower Shielding Reactor, i.e., those applicable to a seismic event requiring the experimental area to be checked for hazards by knowledgeable staff before personnel enter the area; 3) implement radiation protection controls requiring that a survey be completed by Radiation Protection personnel to verify acceptable radiation levels prior to granting access to a radiological area; and 4) remove the fork-lift from Building 7708 to eliminate a potential fire hazard and transfer the fuel pins to the Y-12 area for long-term storage to eliminate the potential of an activity release in the same building (completed January 1994). All of these corrective actions plans have been completed and are being implemented (Holt 1993; ORNL 1994; DOE 1994b; Wichmann 1995a, b).

Present options being discussed for storage of this fuel include shipment to the Savannah River Site or onsite dry storage at ORNL. Because this reactor is shut down, no additional elements are expected to accumulate through the year 2035 (Holt 1993; ORNL 1994).

2.3.5.3 Bulk Shielding Reactor. The 2 megawatt Bulk Shielding Reactor is an open pool, light water moderated and reflected, training and research reactor. This reactor was built in 1951 and shut down in 1991; there are no plans for resumption of operations at this time (ANS 1988; DOE/OSTI 1993; DOE 1993b).

The Bulk Shielding Reactor is shut down and currently has no elements in the reactor or in on-site dry storage. Seventy-three of 90 storage locations are occupied in the onsite wet storage. There are 41 elements from the Bulk Shielding Reactor and 32 elements from the Oak Ridge Research Reactor for a total of 0.010 MTHM in the storage area. As the reactor is shut down, no additional fuel is expected to be added to the inventory through the year 2035; therefore, no expansion of storage facilities onsite is expected (DOE 1993b; Wichmann 1995a, b).

2.3.5.4 Oak Ridge Research Reactor. The Oak Ridge Research Reactor was shut down permanently in 1987 and has been defueled. Most of the fuel was transported to the Savannah River Site, but some of the fuel was transferred to the Bulk Shielding Reactor pool. Refer to the discussion of the spent fuel inventory in subsection 2.3.5.3 (Holt 1993; ANS 1988; ORNL 1992b).

2.3.5.5 Molten Salt Reactor Experiment. The Molten Salt Reactor Experiment operated from June 1965 to December 1969 at a nominal power level of 8 megawatts. The purpose of the reactor was to test the practicality of a molten-salt reactor concept for central power station applications. The circulating fuel solution was a mixture of fluoride salts containing uranium fluoride as the fuel. The initial charge was uranium-235, but this was later replaced with a charge of uranium-233. Processing capabilities were included as part of the facility for on-line

fuel additions, removal of impurities, and uranium recovery. Following reactor shutdown, the fuel and flush salts were drained to critically safe storage tanks and isolated (Hargrove 1993).

The inventory at the Molten Salt Reactor Experiment consists of approximately 4,650 kilograms (9,514 pounds) of fuels salt mixture. The uranium salt is predominantly uranium-233 (31 kilograms [68 pounds]) with lesser amounts of uranium-234, uranium-235, and uranium-238. The balance of the fuel salt is composed of lithium fluoride (LiF, 64.5 percent), beryllium fluoride (BeF_2, 30.3 percent), and zirconium fluoride (ZrF_4, 5.0 percent). The Molten Salt Experiment contains 0.037 MTHM as the reactor is shutdown, no additional SNF is expected to be generated through the year 2035 (DOE 1993b; Hargrove 1993; Wichmann 1995a, b).

Radioactive material migration has been detected from the storage tanks. This vulnerability could result in unnecessary personnel exposure. If left unabated, radiation levels could increase to a point where access would be difficult. ORNL is determining appropriate corrective actions and expects to implement its corrective action plan during fiscal year 1995 (DOE 1994b; 1993b).

2.3.5.6 KEMA Suspension Test Reactor. The KEMA Suspension Test Reactor was an experimental fluidized bed test reactor. The fuel, consisting of one core, was placed in Solid Waste Storage Area 6 and totals 0.037 MTHM. The area of Solid Waste Storage Area 6 where the fuel was placed is being managed by DOE as part of waste area grouping 6, an environmental restoration program activity, under the Comprehensive Environmental Response, Compensation, and Liability Act. As the reactor is shutdown, no additional SNF is expected to be generated through the year 2035 (Wichmann 1995a, b).

2.3.5.7 Advanced Neutron Source Reactor. The Advanced Neutron Source Reactor is currently in the conceptual design stage and has been proposed to be operational in the year 2002 or 2003. Its principal purpose will be for neutron beam experiments, but it will also be used for some isotope production (Holt 1993; DOE/OSTI 1993).

Since the current schedule projects initial operation of the Advanced Neutron Source Reactor in the year 2002 or 2003, spent fuel is not expected to be generated until 2004. Estimates are that 18 elements per year will be discharged. (For handling and storage purposes, an element is an integral core assembly composed of two concentric fuel plates.) A total of 576 SNF elements are predicted to be produced if the reactor is in operation from the years 2002 through 2035 (Holt 1993). As this reactor is in the conceptual design stage, the SNF expected to be generated is not included in the SNF Inventory Data.

3. SPENT NUCLEAR FUEL ALTERNATIVES

This chapter describes the spent nuclear fuel (SNF) management alternatives evaluated by the U.S. Department of Energy (DOE) for this Programmatic Environmental Impact Statement (EIS) that are applicable to the Oak Ridge Reservation (ORR). The ORR generates and stores SNF as a result of reactor research activities. Unlike the Hanford Site, the Idaho National Engineering Laboratory (INEL), and the Savannah River Site (SRS), SNF management is only a minor part of the ORR mission. Therefore, the No Action, Decentralization, and 1992/1993 Planning Basis alternatives could have minimal to no impact on ORR operations. However, the Regionalization and Centralization Alternatives would produce major impacts on ORR operations.

3.1 Description of Management Alternatives

3.1.1 Alternative 1 - No Action

The No-Action Alternative is restricted to the minimum actions necessary for the continued safe and secure management of SNF. As defined, this alternative stipulates no SNF shipments to or from DOE facilities. While the ORR generates and stores SNF as a result of reactor research activities, it does not receive SNF from offsite generators except occasionally in small quantities for specific research assignments. No offsite SNF would be shipped to the ORR under this alternative, nor would SNF be shipped offsite, which could affect the planned shipment of High Flux Isotope Reactor assemblies to the SRS. SNF storage capacity at the ORR for the existing High Flux Isotope Reactor would be adequate only through the year 2002. This could result in the shutdown of this reactor after this date. The proposed Advanced Neutron Source Reactor would need to consider this situation in the design and operation activities.

The environmental effects of the No-Action Alternative are essentially the same as those of current onsite SNF storage and are included in the affected environment discussions covering current site operations.

Implementation of the No-Action Alternative at ORR could lead to the shutdown of the High Flux Isotope Reactor as a result of filling the SNF storage capacity. If the High Flux Isotope Reactor were shutdown, it would eliminate the national capacity to provide transuranic isotopes, eliminate the only western-world source of some medical isotopes, and eliminate the nationally and internationally important capability for research and development in the structure of materials and irradiation effects on materials (Brown 1994a; Hoel 1994).

This alternative for the ORR is not analyzed or discussed further in this or subsequent chapters except in the Facility Accidents section, 5.15.

3.1.2 Alternative 2 - Decentralization

Decentralization involves storage of SNF at or close to generation sites. Under this alternative no offsite SNF would be shipped to the ORR nor would SNF be shipped offsite. The environmental effects of this alternative are the same as those of the No-Action Alternative. The environmental effects of current onsite SNF storage are included in the affected environment discussions covering current site operations. Consequently, this alternative is not analyzed or discussed further in this or subsequent chapters for the ORR. Construction of new SNF storage facilities could be initiated under this option.

The Decentralization Alternative would allow DOE to upgrade and/or replace facilities for the management of the SNF currently located on site. This alternative would allow for continued operation of the High Flux Isotope Reactor by allowing new dry-storage facilities for newly generated and existing SNF in the High Flux Isotope Reactor pool. To allow the High Flux Isotope Reactor to continue operations until a dry storage facility is available, a dry-storage cask may be acquired. DOE could propose an interim, retrievable, aboveground, dry-storage facility for consolidating the SNF at ORR. DOE could also prepare facilities as necessary for the characterization and packaging of SNF for interim storage. The fuel in the Molten Salt Reactor Experiment reactor would need conditioning and stabilization before being relocated to the new facility, or the Molten Salt Reactor Experiment fuel would need special storage facilities (Brown 1994a; Hoel 1994).

3.1.3 Alternative 3 - 1992/1993 Planning Basis

The 1992/1993 Planning Basis Alternative is DOE's documented 1992/1993 plan for the management of DOE and Naval SNF. This plan would include the shipment of SNF from the ORR to other DOE sites as necessary to permit continued operation of ORR research reactors. The environmental effects of current onsite SNF storage are included in the affected environment discussions covering current site operations. Under this alternative, the amount of SNF storage at ORR would not increase. Therefore, this alternative would not have a measurable impact on the environment since there would be no changes to current ORR operations. Consequently, this alternative is not analyzed or discussed further in this or subsequent chapters for the ORR.

At ORR, this alternative would be very similar to the Decentralization alternative except that some SNF would be shipped to SRS. The SNF currently stored at the High Flux Isotope Reactor and Bulk Shielding Reactor pools, and at the Tower Shielding Reactor would be shipped to SRS. Only 20 elements from the High Flux Isotope Reactor can be shipped to SRS unless other arrangements can be made. If the quantity of High Flux Isotope Reactor fuel that can be shipped to SRS is limited to 20 elements, then the High Flux Isotope Reactor will require dry-storage facilities to continue operation. DOE could prepare an interim, retrievable, aboveground, dry-storage facility for consolidating the SNF remaining at ORR. This facility would be similar to the one built under Alternative 2 except it would probably be smaller (Brown 1994a; Hoel 1994).

3.1.4 Alternative 4 - Regionalization

3.1.4.1 Overview. The Regionalization Alternative consists of two subalternatives. Subalternative A would distribute existing and new SNF between the Hanford Site, INEL, and SRS by SNF type. Under Subalternative B, SNF would be distributed to either an eastern or western regional site based on geographical location. SNF east of the Mississippi River would be shipped to the eastern regional site (i.e., SRS or ORR). SNF west of the Mississippi River would be shipped to the western regional site (i.e., Hanford Site, INEL, or Nevada Test Site [NTS]). Additionally all Naval SNF would be shipped to only one of the regional sites, but not both. A regional site will only receive all the Naval fuel if also selected as the Naval site. The ORR would be the alternative to the SRS as the eastern regional site, and the NTS would be the alternative to both the Hanford Site and INEL as the western regional site.

3.1.4.2 Regionalization Subalternative B. The following fuels would be transported to the ORR for storage under the Regionalization Subalternative B:

- Naval-type SNF (if selected)
  - All, including from the INEL, shipyards, and prototypes
- Hanford Production SNF
  - From eastern sites
- Graphite SNF
  - From eastern sites
- DOE-owned commercial SNF
  - From eastern sites, including the West Valley Demonstration Project and B&W Lynchburg
- Experimental - Stainless Steel SNF
  - From eastern sites, including the Foreign Research Reactors, and non-DOE domestic research reactors
- Experimental - Zirconium SNF
  - From eastern sites, including the SRS
- Experimental - Other
  - From eastern sites
- SRS Production and Aluminum SNF
  - From eastern sites, including SRS, Brookhaven National Laboratory, Foreign Research Reactors, and non-DOE domestic research reactors.

All SNF presently in storage at DOE facilities would arrive at the ORR stabilized and canned to the extent necessary for safe transportation. However, this SNF may need to be uncanned, stabilized, prepared, and recanned at the ORR to ensure safe interim storage. New non-DOE domestic and Foreign Research Reactor SNF would arrive in a state necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the ORR to

ensure safe interim storage. All fuel would be cooled for a minimum of 120 days prior to shipping and 5 years before being placed in dry storage.

The ORR currently has only limited-capacity facilities suitable for receiving, canning, storing, or supporting the research activities necessary for the safe management of SNF. As a result, a new SNF management complex would be built at the ORR under the Regionalization Subalternative B. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility
- Interim dry storage area
- Expended Core Facility similar to the one currently at the INEL (if selected for Naval fuel receipt).

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The technology development facility would investigate the applicability of dry storage technologies and pilot-scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. If ORR is selected for Naval fuel receipt, Naval SNF would be examined at the Expended Core Facility prior to being turned over for interim storage management.

The SNF management complex which would be built at the ORR under the Regionalization Alternative would have the same components as that built under the Centralization Alternative. The dry storage component would be smaller, however, due to the smaller SNF inventory that would be transported to the ORR under the Regionalization Alternative. The other components of the SNF management complex would be the same general size as those built under the Centralization Alternative. This is because the inventories of new uncanned fuel which would be sent to the ORR under the Regionalization and Centralization Alternatives would be very similar. Additionally, since the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components, the Regionalization Alternative is not analyzed separately but is compared to the Centralization Alternative in a semiquantitative manner.

If the ORR was not chosen as the eastern regional site, all SNF at the ORR would be shipped to the SRS. An exception would be those fuels for which there is no available technology for stabilization to permit safe transport. There is a small quantity of SNF from the Molten Salt Reactor Experiment that is stored in tanks at the ORR. Currently, technology to stabilize this SNF for transport does not exist. Under this alternative, if ORR were to ship SNF to the SRS, this Molten Salt Reactor Experiment SNF would continue to be stored at the ORR until it could be stabilized for safe shipment.

Based on the projected schedule for operation of additional regional SNF storage facilities, the option for acquiring dry storage facilities at the ORR would be maintained to ensure continued High Flux Isotope Reactor operation (Brown 1994a; Hoel 1994).

3.1.5 Alternative 5 - Centralization

3.1.5.1 Overview. Under the Centralization Alternative, all existing and new SNF would be shipped to one DOE site. There are five Centralization options considered in this EIS: the Hanford Site, the INEL, the SRS, the NTS, and the ORR. If the ORR was chosen as the centralization site all SNF stored at the Hanford Site, INEL, SRS, and other sites currently storing DOE fuel would be transferred to the ORR.

3.1.5.2 Centralization Alternative Option D. The following fuels would be transported to the ORR for storage under Centralization Alternative Option D:

- Naval-type SNF
  - From the INEL, shipyards, and prototypes
- Hanford Production SNF
  - From the Hanford Site
- Graphite SNF
  - From the INEL and the Public Service of Colorado

- DOE-owned commercial SNF
  - From the Hanford Site, INEL, West Valley Demonstration Project, and B&W Lynchburg
- Experimental - Stainless Steel SNF
  - From the Hanford Site, INEL, SRS, Foreign Research Reactors, and non-DOE domestic research reactors
- Experimental - Zirconium Clad SNF
  - From the INEL and SRS
- Experimental - Other
  - From the ORNL
- SRS Production and Aluminum Clad SNF
  - From the INEL, SRS, ORNL, Los Alamos National Laboratory, Brookhaven National Laboratory, Foreign Research Reactors, and non-DOE domestic research reactors.

All SNF presently in storage at DOE facilities would arrive at the ORR stabilized and canned to the extent necessary for safe transportation. However, this SNF may need to be uncanned, stabilized, prepared, and recanned at the ORR to ensure safe interim storage. New non-DOE domestic, Foreign Research Reactor, and Naval SNF would arrive in a state necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the ORR to ensure safe interim storage. All fuel would be cooled a minimum of 120 days prior to shipping and 5 years before being placed into dry storage. Additionally, Naval SNF would be examined at the ORR before it was turned over for interim storage management.

Although the ORR has a number of experimental and pilot facilities, probably none of them is suitable for receiving, canning, storing, or supporting research activities necessary for the safe management of SNF, unless they are extensively upgraded and expanded. As a result, a new SNF management complex would be built at the ORR under the Centralization Alternative Option D. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility

- Interim dry storage area
- Expended Core Facility for Naval-type fuel similar to the one currently at the INEL.

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The technology development facility would investigate the applicability of dry storage technologies and pilot-scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval SNF would be examined at a new Expended Core Facility constructed at the ORR prior to being turned over for interim storage management.

The SNF management complex which would be built at the ORR under the Centralization Alternative would have the same components as that built under the Regionalization Alternative. However, the dry storage component would be about 10 times larger, due to the larger SNF inventory that would be transported to the ORR under the Centralization Alternative. The other components of the SNF management complex would be the same general size as those built under the Regionalization Alternative. This is because the inventories of new uncanned fuel which would be sent to the ORR under the Centralization and Regionalization Alternatives would be very similar. Additionally, the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components and would not be significantly different for the Regionalization Alternative. Therefore, this alternative is used as the basis for a semiquantitative comparison with the Regionalization Alternative.

If the ORR is not chosen as the centralization site, all SNF at the ORR would be shipped to the selected centralization site. An exception would be those fuels for which there is no available technology for stabilization to permit safe transport. There is a small quantity of SNF from the Molten Salt Reactor Experiment that is stored in tanks at the ORR. Currently, technology to stabilize this SNF for transport does not exist. Under this alternative, if ORR were to ship SNF to the SRS, this Molten Salt Reactor Experiment SNF would continue to be stored at the ORR until it could be stabilized for safe shipment.

Based on the projected schedule for operation of additional centralized SNF storage facilities, the option for acquiring dry storage facilities at the ORR would be maintained to ensure storage facilities at the ORR would be maintained to ensure continued High Flux Isotope Reactor operation (Brown 1994a; Hoel 1994).

3.2 Comparison of Alternatives

Table 3.2-1 shows a comparison of the alternatives. The Regionalization Alternative column does not include the requirements of the Naval Expended Core Facility, although this facility may be constructed at the site under this alternative. The Centralization Alternative column does include the requirements of the Naval Expended Core Facility, which are presented in Volume 1, Appendix D, since this facility will be built at the site under this alternative.

Table 3.2-1. Comparison of alternatives at the Oak Ridge Reservation.

Parameter	Regionalization Subalternative B at ORR	Centralization Option D[a]
Land for new facilities (acres)	90	120
Site area (acres)	34,667	34,667
Percent of site area	0.26	0.35
SNF-related employment[b]	556	1,118
Baseline site employment	17,082	17,082
Percent of baseline site employment	3.3	6.5
Estimated maximum latent cancer fatalities in 80-km population per year, SNF management operations[c]	2.5×10^{-3}	2.5×10^{-3}
Estimated cancer fatalities in 80-km population per year, other site operations	2.7×10^{-2}	2.7×10^{-2}
Estimated probability of cancer fatalities in MEI per year, SNF management operations[c]	3.1×10^{-6}	3.1×10^{-6}
Estimated probability of cancer fatalities in MEI per year, other site operations	9.2×10^{-6}	9.2×10^{-6}
Estimated probability of cancer fatality in average worker per year, SNF management operations[c]	1.6×10^{-5}	1.6×10^{-5}
Estimated probability of cancer fatality in average worker per year, other site operations	1.1×10^{-6}	1.1×10^{-6}
Water use (million gallons) per year, SNF management	3.6	6.1
Baseline water use (million gallons) per year, site operations	6,680	6,680
Percent of baseline site water use	0.05	0.09
Electricity use (megawatt-hours) per year, SNF management	23,000	33,000

Table 3.2-1. (continued).

Parameter	Regionalization Subalternative B at ORR	Centralization Option D[a]
Baseline electricity use (megawatt-hours) per year, site operations	1,000,000	1,000,000
Percent of baseline site electricity use	2.30	3.30
Sewage discharge (million gallons) per year, SNF management	3.6	6.1
Baseline sewage discharge (million gallons) per year, site operations	200	200
Percent of baseline site sewage discharge	1.8	3.1
High-level waste (cubic meters) per year, SNF management	0	0
Transuranic waste (cubic meters), SNF management	16	16
Mixed waste (cubic meters), SNF management	0	0
Low-level waste (cubic meters), SNF management	203	628
Estimated maximum cancer fatalities in 80-km population from maximum risk accident[d]	2.1×10^{-2}	
Frequency of occurrence (number per year)[d]	1.6×10^{-1}	
Estimated maximum risk of cancer fatalities in 80-km population from maximum risk accident (cancer fatalities per year)[d]	3.4×10^{-3}	
Estimated maximum worker cancer fatalities from maximum risk accident[d]	1.9×10^{-3}	
Frequency of occurrence (number per year)[d]	1.0×10^{-4}	
Estimated maximum risk of worker cancer fatalities from maximum risk accident (latent cancer fatalities per year)[d]	1.9×10^{-7}	

a. Centralization Option includes the Naval Expended Core Facility (ECF) results from Volume 1, Appendix D. Centralization without ECF would be the same as for Regionalization.
b. Annual average SNF direct construction and operation jobs over the 10-year period 1995 to 2005.
c. Excludes baseline site operations.
d. Centralization Option is the same as the Regionalization Option for the SNF Management Facility and does not include the Naval Expended Core Facility accident analyses results from Volume 1, Appendix D.

4.0 AFFECTED ENVIRONMENT

4.1 Overview

This chapter describes the existing environmental conditions in areas potentially affected by a programmatic decision to site spent nuclear fuel (SNF) facilities at the Oak Ridge Reservation (ORR) under the Centralization and Regionalization alternatives. Topics were selected for analysis based upon their potential to be affected by these alternatives. Each topic is addressed in the detail necessary to serve as a baseline for assessment of potential environmental consequences in Chapter 5.

4.2 Land Use

The ORR occupies an area of approximately 34,667 acres (140 square kilometers) in eastern Tennessee, in a predominantly rural area about 25 miles (40 kilometers) west of Knoxville. The ORR, which is bordered on the southeast and southwest by the Clinch River, is within the jurisdictional boundaries of the City of Oak Ridge, and also lies within Roane and Anderson Counties (MMES 1989).

The ORR consists of three plants located on three separate sites: the Y-12 Plant (1.3 square miles or 3.4 square kilometers); the Oak Ridge National Laboratory (ORNL) (1.8 square miles or 4.7 square kilometers); and the K-25 Site (1.1 square miles or 2.8 square kilometers) (MMES 1989).

Land use activities at the ORR have historically occurred within the boundaries of the three main plant sites. However, more recently, other ORR lands have also begun to be used. ORR land was first utilized for waste storage in the mid-1940s and for environmental research in the 1950s. A forestry management program was initiated in 1964, and the first comprehensive forest management program was released in 1965. The ORR has been used by research institutions, universities, and government agencies as a site for the study of terrestrial ecology, aquatic ecology, forestry, and agriculture. In 1980, Department of Energy (DOE) designated approximately 21 square miles (54 square kilometers) of undeveloped ORR land as a National

Environmental Research Park, which today provides protected land areas for research and education in the environmental sciences (MMES 1989).

Land use outside the three main plant sites falls into seven general categories: multi-purpose research and development; support services; waste management; environmental restoration; natural areas; public recreational park; and national environmental research park (Figure 4.2-1). Approximately 58 percent of the land on the ORR (20,051 acres or 31 square miles) can be classified as undeveloped due to its current land use designation (MMES 1994a).

Land uses bordering the ORR are primarily forest and agricultural. Residential and commercial are the only other significant uses of land in the vicinity, and occur along the northeast and northwest boundary of the ORR in the City of Oak Ridge. The land areas bordering the ORR comprise woodlands (mostly hardwood forests), small farms, and rural residences. Commercial forestry and agriculture account for approximately 76 percent of the total land use in this region (MMES 1994a).

The entire ORR has been placed under the forestry, agriculture, industry, and research zoning classification by the City of Oak Ridge, although this designation does not bind DOE land use decisions on the site. DOE land use plans applicable to the ORR include the *Oak Ridge Reservation Site Development and Facilities Utilization Plan*, issued in 1989 and updated in 1990; the *City of Oak Ridge Comprehensive Plan and Zoning Ordinance*, issued in 1985 and updated in 1988; and the *Resource Management Plan for the U.S. DOE Oak Ridge Reservation*, first issued in 1984.

The region surrounding the ORR has numerous local, state, and national public recreation areas (Figure 4.2-2). Federal outdoor recreation facilities include the Great Smoky Mountains National Park; the Cherokee National Forest; the Cumberland Gap National Historic Park; the Big South Fork National River and Recreation Area; and the Obed Wild and Scenic River (MMES 1994a). State parks near the ORR site include the Frozen Head State Natural Area; the Big Ridge State Park; the Cove Lake State Park; the Fall Creek Falls State Park; the Pickett State Rustic Park; the Panther Creek State Park; and the Hiwassee State Scenic River (MMES 1994a).

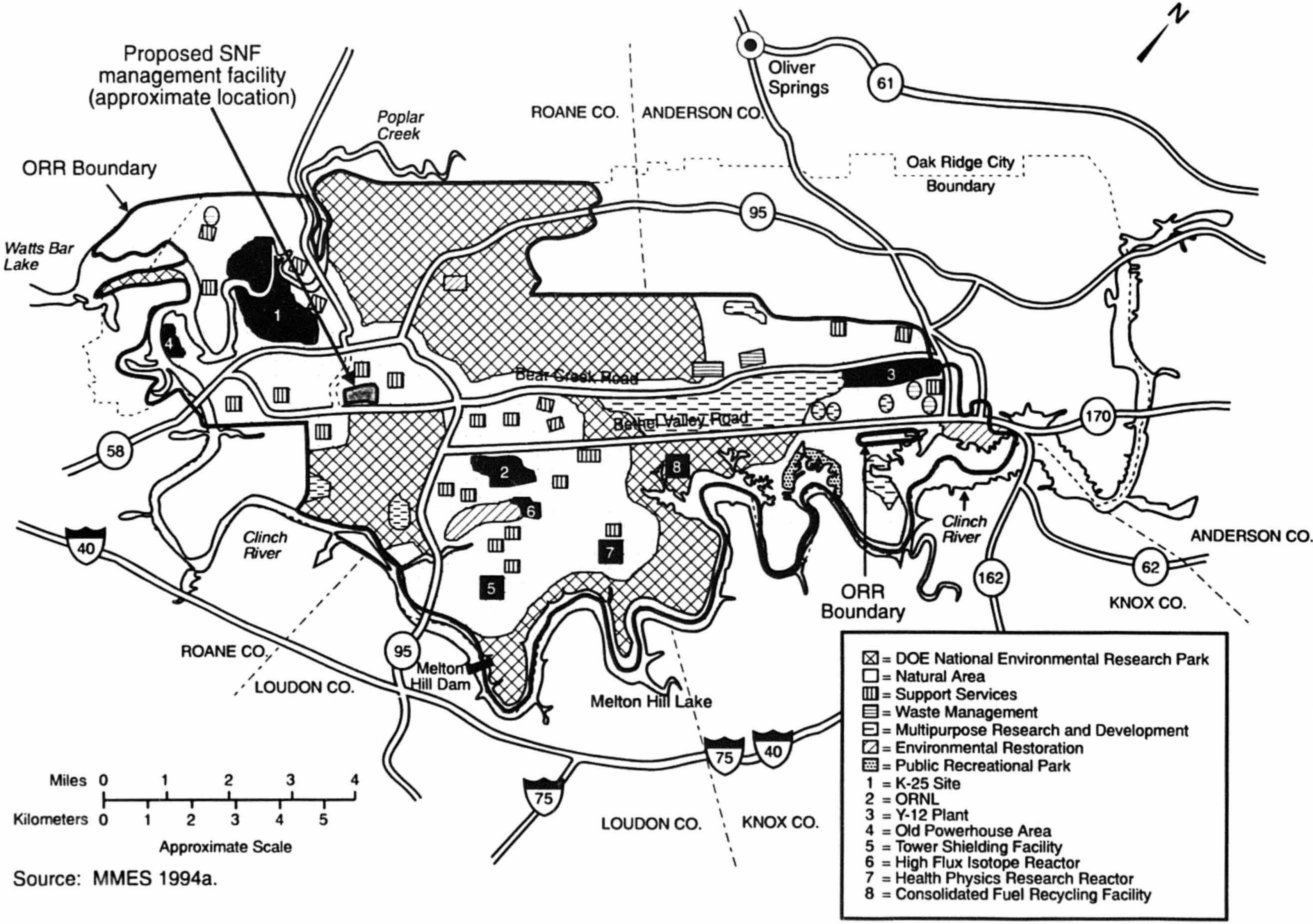


Figure 4.2-1. Generalized land use at the Oak Ridge Reservation.

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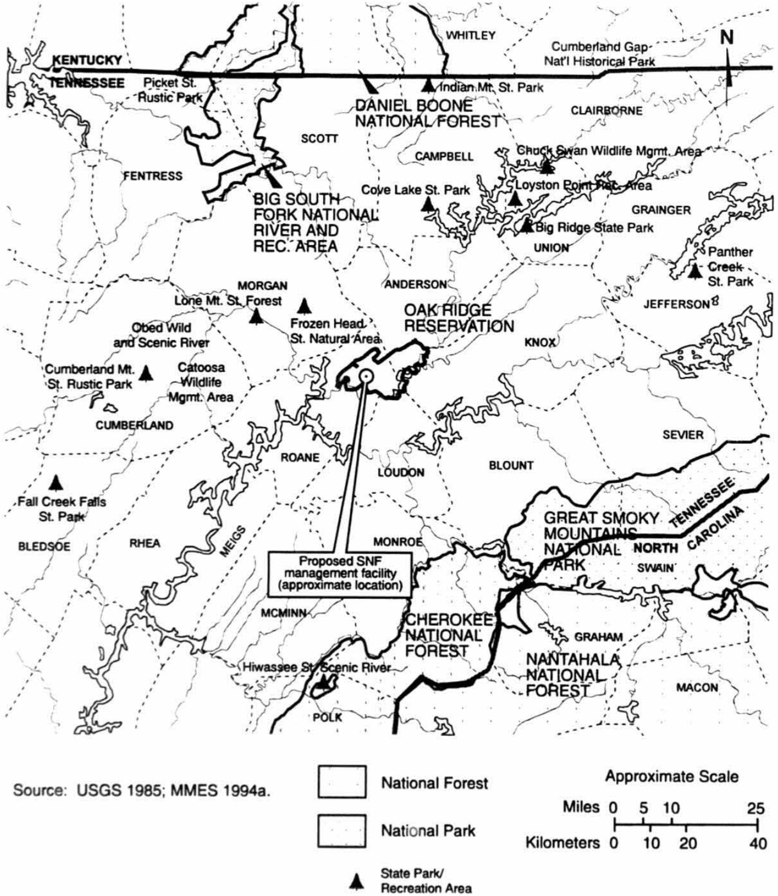


Source: USGS 1985; MMES 1994a.

Figure 4.2-2. Recreation areas in the vicinity of the Oak Ridge Reservation.

Several lakes exist within the ORR surrounding region, offering year-round recreational activities such as fishing and boating. Wildlife management areas that allow in-season hunting include the Big South Fork National River and Recreation Area, Catoosa Wildlife Management Area, Chuck Swan Wildlife Management Area, and the ORR (MMES 1994a).

Numerous locally funded recreational areas exist near the ORR, the closest being in the City of Oak Ridge. The City of Oak Ridge has 2 golf courses, 11 athletic fields, 36 tennis courts, 12 playground areas, and a public outdoor swimming pool (MMES 1994a).

Clark Center Recreational Park, located on the ORR, is a 90-acre (0.36-square-kilometer) recreational area that is open to the public. The park consists of three shelters, a boat ramp, two softball fields, a swimming area, and a paved access road. It is located approximately 2 miles (3.2 kilometers) south of the Y-12 Plant (MMES 1994a).

The ORR is a controlled area with public access limited to through traffic on Tennessee State Routes 95, 58, 62, 162, and 170 (MMES 1991b).

The site proposed for SNF activities is located within the West Bear Creek Valley Area, located in the western portion of the ORR site near the site boundary. This area of the ORR is currently in the Natural Areas land use category and is designated for future Waste Management land use (MMES 1994a). The area is designated as a Potential Site for a Future Programmatic Initiative in the most recent ORR Master Plan (MMES 1994a). With the exception of an industrial park, land uses bordering the ORR in the area of West Bear Creek Valley are primarily agricultural farmland and commercial forest, with sparsely located residences (MMES 1994a).

The industrial park located just to the south of the proposed SNF management facility on Bear Creek Road houses two organizations. The Scientific Ecology Group, Inc., employs about 700 to 800 people and is a low-level radioactive waste incinerator who's commercial operation began in 1989. International Technology, Inc., operates a hazardous and radioactive waste geotechnical laboratory and a pilot lab, also on Bear Creek Road. This International

Technology, Inc., operates a hazardous and radioactive waste geotechnical laboratory and a pilot lab, also on Bear Creek Road. This International Technology, Inc., facility is an extension of the Knoxville office and employs about 10 people at the facility (IT undated a, undated b; SEG undated).

There are no onsite areas that are subject to Native American Treaty rights or contain any prime or unique farmland.

4.3 Socioeconomics

4.3.1 Region of Influence

The socioeconomic information presented in this Programmatic Environmental Impact Statement covers the baseline conditions in the Region of Influence. The Region of Influence is defined as the region in which the principal direct and indirect socioeconomic effects of actions at the ORR are likely to occur and are expected to be of consequence for local jurisdictions. The Region of Influence includes the current residential distribution of the DOE and contractor personnel employed by the ORR, the probable location of offsite contractor operations, and the probable location of labor and capital supporting indirect economic activity linked to the ORR. The Region of Influence includes the counties where 92 percent of DOE and contractor personnel employed by ORR reside. The Region of Influence includes the counties of Anderson, where 34 percent of ORR personnel reside, Knox (36 percent), Roane (16 percent), and Loudon (6 percent) (Truex 1991 [Table J]).

4.3.2 Regional Economic Activity and Population

Regional economic linkage supporting production activity at the ORR occurs primarily with Anderson, Knox, and Roane counties, where most of the supporting contractors offsite and labor and capital supporting indirect economic activity linked to the ORR are located.

4.3.2.1 Anderson County. Most of the industrial and commercial development, dominated by energy-related companies specializing in manufacturing and research and development in support of the ORR, has occurred in the City of Oak Ridge in Anderson County and Roane County.

The major employment sectors in Anderson County in 1990 were services, manufacturing, government, and retail trade. As a percentage of Anderson County wage and salary employment, the service and manufacturing sector each accounted for 30 percent, the government sector 13 percent, and retail trade 11 percent. The number of employed persons in Anderson County in 1990 was 39,596. Jobs in Anderson County have increased 3 percent annually between 1980 and 1990, and are projected to continue to increase at an average rate of less than 1 percent annually for the next several years (U.S. Department of Commerce 1993). Since 1988, the unemployment level for Anderson County has remained below the national unemployment rate. The unemployment rate reached a low of 4.4 percent in 1990 and has slowly increased to 5.6 percent in 1992 (Anderson County 1993; Department of Economic and Community Development Industrial Development Division 1993).

Approximately 40 percent of the Anderson County population resides in the City of Oak Ridge, with an additional 42 percent in rural areas, and the remaining 18 percent in other municipalities in Anderson County (Anderson County 1993). Between 1980 and 1990, the population in Anderson County increased by over 1 percent from 67,500 to 68,250 persons (0.10 percent annually). The population in Anderson County is projected to continue to grow at an average rate of less than 1 percent annually over the next several years, reaching 76,100 persons by 2004 (U.S. Department of Commerce 1993).

4.3.2.2 Knox County. In Knox County, the major employment sectors in 1990 were service, manufacturing, retail trade, and government. As a percentage of Knox County wage and salary employment, the service sector accounted for approximately 27 percent, retail trade 20 percent, manufacturing 12 percent, and government 17 percent. The total number of persons employed in Knox County in 1990 was 215,948. Jobs have increased 2 percent annually between 1980 and 1990, and are projected to continue to grow at an average rate of less than 1 percent annually for the next several years (U.S. Department of Commerce 1993). The unemployment rate for Knox County was 4.6 percent in 1992 (Department of Economic and Community Development Industrial Development Division 1992).

Between 1980 and 1990, the population in Knox County increased 5 percent from 319,700 to 335,750. The population in Knox County is projected to continue to increase at an average rate of less than 1 percent annually for the next several years, reaching 377,130 persons by 2004 (U.S. Department of Commerce 1993).

4.3.2.3 Roane County. Development that has occurred in Roane County has been predominantly residential. In Roane County, the major employment sectors in 1990 were retail trade, manufacturing, services, and government. As a percentage of wage and salary employment in Roane County, retail trade accounted for approximately 26 percent, manufacturing 24 percent, services 22 percent, and government 15 percent. The total number of persons employed in Roane County in 1990 was 24,640. Jobs have increased less than 1 percent annually between 1980 and 1990, and are projected to continue to increase at an average rate of less than 1 percent annually for the next several years (U.S. Department of Commerce 1993). The unemployment rate for Roane County was 6.8 percent in 1992 (East Tennessee Development District 1993).

Between 1980 and 1990, the population in Roane County decreased 2.5 percent, from 48,430 to 47,230. The population in Roane County is projected to increase at an average rate of less than 1 percent annually for the next several years, reaching 52,670 persons by 2004.

4.3.2.4 Loudon County. Total employment in Loudon County in 1990 was 12,560 persons. In 1990, the farming sector accounted for a considerably larger percentage, while the services and government sector accounted for a smaller percentage of total jobs than in Anderson, Knox, and Roane counties (U.S. Department of Commerce 1993). The unemployment rate for Loudon County was 6.7 percent in 1992, dropping from 7.2 percent in 1991 due to increase in construction and mining jobs (East Tennessee Development District 1993).

The population of Loudon County increased by 1 percent annually, from 28,700 in 1980 to 31,300 in 1990. The population of Loudon County is projected to increase at an average rate of less than 1 percent annually for the next several years, reaching 32,900 persons by 2004 (U.S. Department of Commerce 1993).

4.3.2.5 Oak Ridge Reservation. The employment level at the ORR in 1994 was 18,200 persons (Truex 1995). In 1993, there were approximately three full-time-equivalent employment positions involved in SNF operations on the ORR (Brown 1994b). Employment levels are expected to decrease to 16,980 by the year 1999 and are projected to remain constant through the year 2004 (Fritts 1994).

4.3.2.6 Aggregate Regional Economic and Demographic Baseline. For the purposes of establishing a regional baseline to compare potential impacts for the programmatic analyses in Section 5.3, regional economic and demographic data for the four-county Region of Influence were aggregated to form one region (Table 4.3-1).

The total population of the Region of Influence, shown in Table 4.3-1, is projected to be 489,230 persons in 1995, and is projected to grow at an annual average rate of less than 1 percent, reaching 538,820 persons in 2004. The labor force of the Region of Influence is also projected to grow at an annual average rate of less than 1 percent, growing to 360,000 persons in 2004. The total employment in the Region of Influence is projected to grow at an annual average rate of approximately 1 percent, growing from 292,700 jobs in 1995 to 338,070 jobs in 2004.

4.3.3 Public Service, Education and Training, and Housing Infrastructure

4.3.3.1 Police and Fire. ORR fire protection services are provided by the fire departments on the reservation. The ORR fire departments have mutual aid agreements among themselves and with the City of Oak Ridge (MMES 1989).

Twelve city, county, and state law enforcement agencies provide police protection in the Region of Influence. In 1990, the largest law enforcement agency in the four-county Region of Influence was in Knoxville, with 296 sworn officers (FBI 1991). Law enforcement on the ORR is provided by the City of Oak Ridge Police Department. Security enforcement, established to meet the Atomic Energy Act and mission requirements, is provided by the prime management and operations contractor (MMES 1989).

Table 4.3-1. Aggregate regional economic and demographic indicators for ORR.[a]

Years	Regional employment	Regional labor force	Regional population
1995	311,700	332,000	506,600
1996	315,100	335,700	510,300
1997	318,600	339,400	51,400
1998	322,100	343,100	517,900
1999	325,700	346,900	521,700
2000	329,300	350,700	525,500
2001	331,500	353,000	528,800
2002	333,700	355,400	532,100
2003	335,900	357,700	535,500
2004	338,000	360,000	538,800
2005	340,300	362,400	542,200
Average Annual Growth Rate	0.9%	0.9%	0.7%

a. Sources: U.S. Department of Commerce 1993; East Tennessee Development District 1993.

Note: Aggregate region includes the Roane, Anderson, Loudon and Knox Counties. Labor force projection developed for this study.

4.3.3.2 Education and Training. Four school districts, Anderson, Knox, Loudon, and Roane, provide public education services in the Region of Influence. In 1990, the four school districts had an average daily membership of 66,510 students. Knox County had the highest average daily membership of 50,324 students (Tennessee Department of Education 1992).

4.3.3.3 Housing. Between 1980 and 1990, the number of housing units in the Region of Influence increased 14 percent from 181,299 to 206,234. In 1980 and 1990, the homeowner vacancy rates in the Region of Influence averaged 1.4 and 1.5 percent, respectively (Census 1982, 1991).

Housing additions in the Region of Influence peaked at 3,882 units in 1990, but declined to 3,662 in 1991. In 1992, however, housing additions increased to a total of 3,880 units (East Tennessee Development District 1993).

4.4 Cultural and Paleontological Resources

4.4.1 Archeological Sites and Historic Structures

For approximately 10,000 years, people have inhabited the ORR site. A cultural resources survey conducted in 1975 did not identify any cultural resources on the proposed site for the SNF management facilities. Therefore, no prehistoric or historic resources are expected to be located on the proposed site for the SNF management facilities (Fielder 1975).

4.4.2 Native American Resources

In the early 1700s, the Overhill Cherokee lived in the area that is now the ORR. The tribe remained in the area until 1838, when it was moved forcibly to Oklahoma under Federal orders (Oakes et al. 1984a). While the Cherokee may retain cultural affiliation with their ancestral home, there are no known Native American resources on the proposed site for the SNF facilities.

4.4.3 Paleontological Resources

The ORR is underlain by nine geologic formations or groups ranging in age from Early Cambrian to Early Mississippian. On the ORR, the only formations known to contain fossils are the Knox Group (which does not usually contain fossils but does contain small coiled gastropods in a limestone bed); the Chickamauga Limestone (which contain many fossils including brachiopods, bryozoans, gastropods, cephalopods, crinoid stems, corals, and trilobites); the Sequatchie Formation (which does not have an abundant supply of fossils in the formation, but does contain large brachiopods, colonial corals, and bryozoans within several thin beds of gray limestone); the Rockwood Formation (which contains crinoid stem fossils in the upper half of the formation); and the Fort Payne Chert, which contains many casts of crinoid stems (McMaster 1988). No unusual paleontological remains from the ORR were identified.

4.5 Aesthetics and Scenic Resources

Visual or scenic resources comprise the natural and man-made features that give a particular environment its aesthetic qualities. These features form the overall impression that a viewer receives of an area or its landscape character. Visual sensitivity is assessed by considering the activities, awareness, and expectations of the public within a given area. High visual sensitivity exists when a view is rare, unique, or in other ways special to viewers. Medium visual sensitivity exists when a view is similar to others in the area or is of secondary importance relative to other significant aspects of the area. Low visual sensitivity exists when a view has little value to viewers and an intrusion or alteration of that view would have no impact on viewers.

Scenic resources at the ORR and the surrounding area are set in a landscape of heavily forested, predominantly parallel ridges with steep slopes interspersed with relatively flat valleys, known physiographically as the Ridge and Valley Province. Due to the rolling topography at the ORR, approximately 62 percent of the reservation is located on slopes of less than 14 percent (MMES 1994a). The reservation is framed by the Clinch River at the west, south, and eastern boundary, and by Poplar Creek to the north. The vegetation present at the reservation is primarily a mixture of deciduous and coniferous forest covering approximately 80 percent of the

site (MMES 1989). Roads providing public access to the interior of the site include State Routes 95 and 58, along with Bethel Valley Road (Figure 4.2-1).

The location of the proposed SNF management facilities, under the Centralization Alternative, is set along the north side of Bear Creek Road west of State Route 95, between the extension of Blair Road and State Route 95, at the western end of the reservation. The public has access to Bear Creek Road west of State Route 95. As a result, the entrance to the site will be visible to traffic on Bear Creek Road (MMES 1994a). The proposed facilities would consist of 90 acres (0.36 square kilometer), 85 of which would be located within security fencing. The facility would have the appearance of industrial buildings ranging in height from one to three stories. The site would receive and unload up to one truck shipment per day, or a total of 5,500 truck shipments over the 40-year operation period. The site would be set on the south side of Pine Ridge midway between the top of the ridge, with elevations ranging between 900 and 1,100 feet (274 and 335 meters), and Bear Creek Valley, with an elevation of approximately 700 feet (213 meters) (TVA 1987). Chestnut Ridge, located south of Pine Ridge on the reservation, faces the site.

Under the Regionalization Alternative, the location of the proposed SNF facility would remain the same but would be reduced in area and extent. Operation of the facilities would also be reduced, resulting in the receipt of fewer truck shipments over the 40-year operation period.

The viewshed surrounding the ORR consists mainly of sparsely populated rural land. The City of Oak Ridge, along the northeast portion of the site, is the only adjacent urban area. Views of DOE facilities from areas surrounding the reservation include those from public roadways such as Interstates 40 and 75, U.S. Route 70, and State Routes 62, 162, and 95. The reservation can also be viewed from the south bluffs along the Clinch River. The Great Smoky Mountains National Park and the Blue Ridge Mountains are approximately 70 miles southeast of the ORR and are generally not visible from the reservation (MMES 1989). In general, views are limited by the rolling terrain, heavily forested vegetation, and hazy atmospheric conditions.

The developed areas of the ORR could generally be classified as having low visual sensitivity. The remainder of the site ranges from low to moderate visual sensitivity. Of the jurisdictions that may be affected by the construction and operation of the proposed SNF facilities, only the City of Oak Ridge in its Comprehensive Plan has provided policies that promote elements of scenic resource enhancement and preservation through streetscape design, landscaping, lighting, and signage improvements at entrances to the urban area and the city center. One entrance to the urban area that promotes scenic resource enhancement and preservation is Illinois Avenue, crossing the northeast portion of the ORR (City of Oak Ridge 1989).

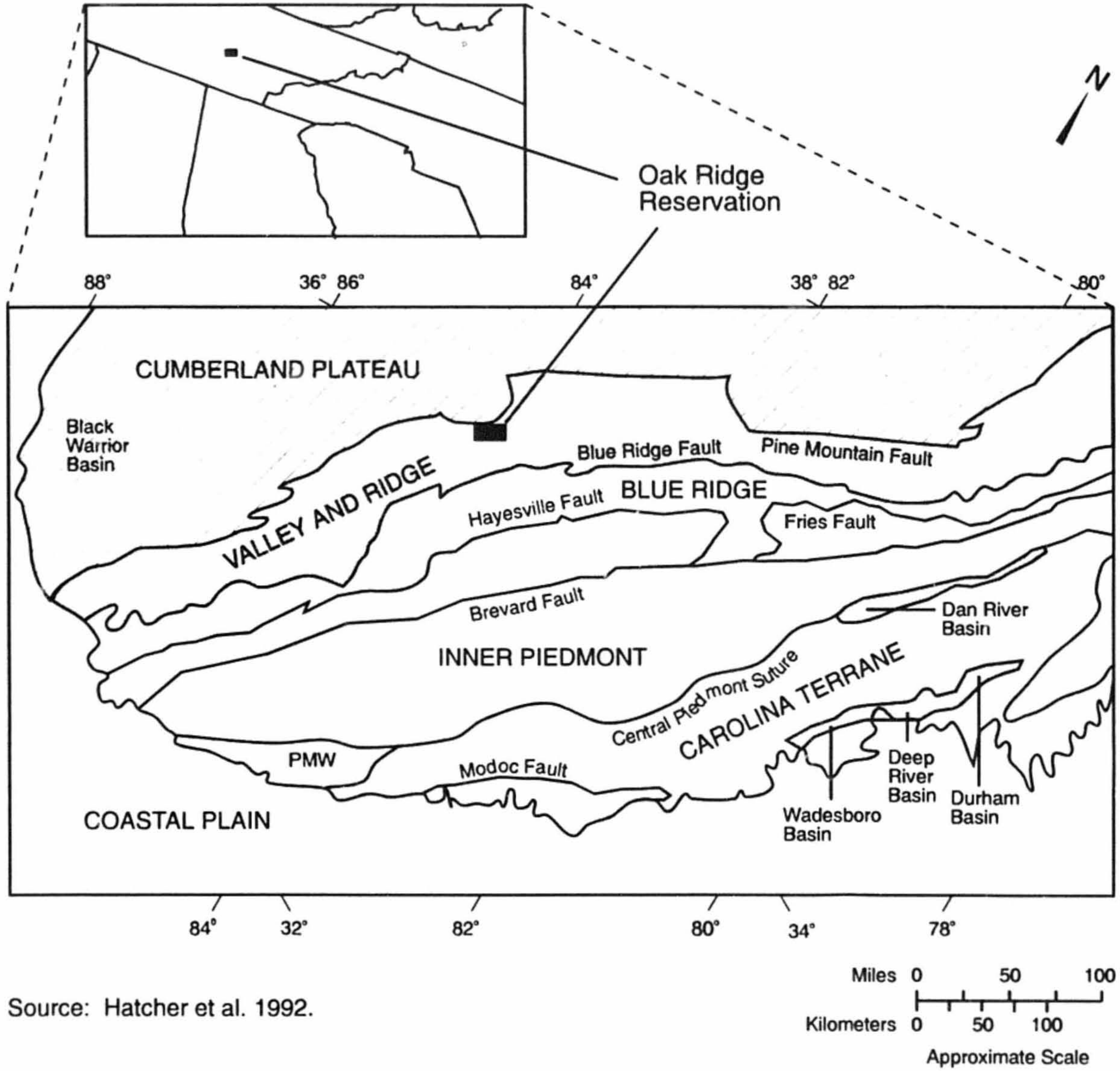
4.6 Geologic Resources

This section provides a general description of the geology, soils, geologic resources, and seismic, volcanic, and other geologic hazards at the ORR and surrounding area. This section also describes any existing impacts to the geology and geologic resources resulting from past and present human activities at the ORR.

4.6.1 General Geology

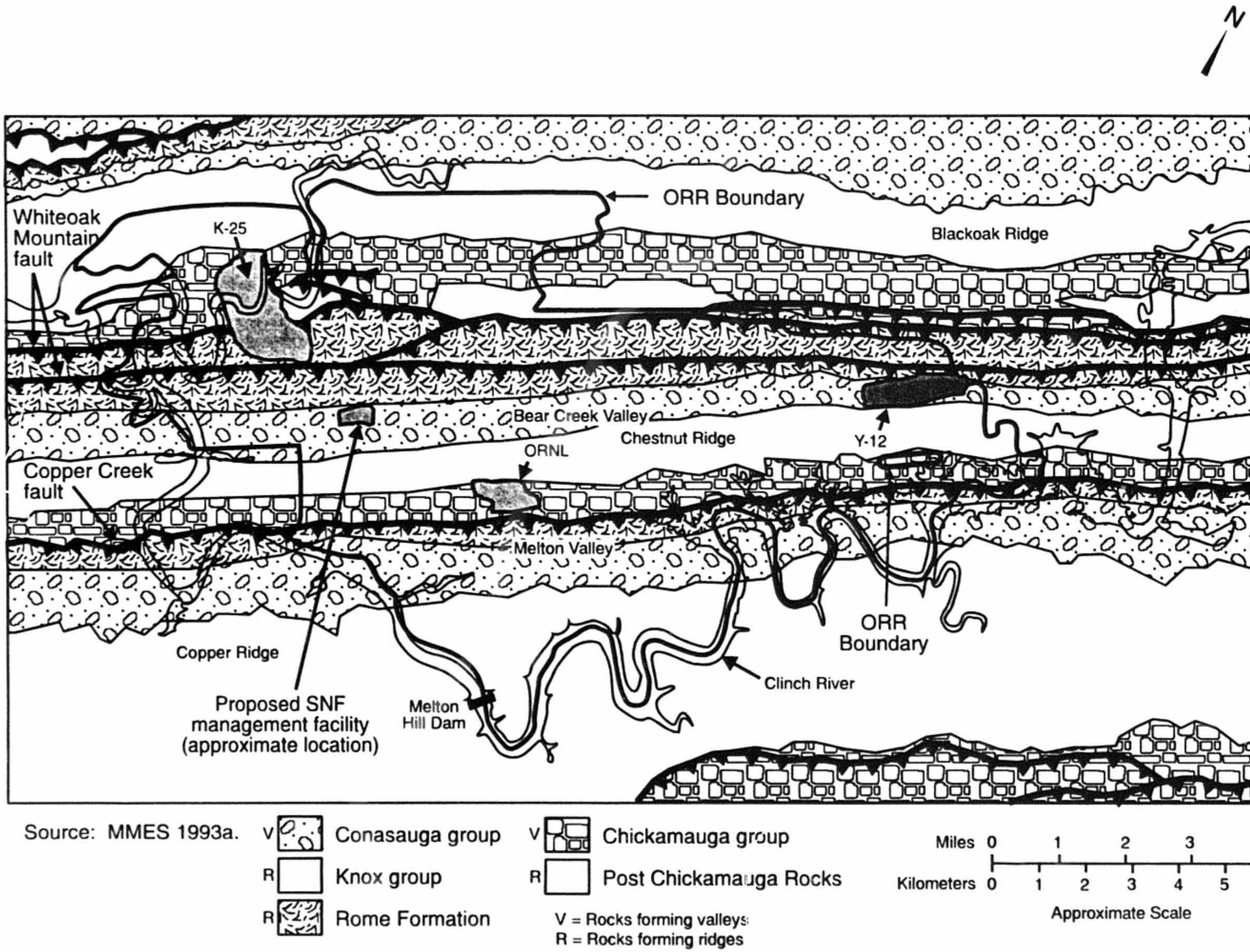
As shown in Figure 4.6-1, the ORR lies entirely within the western portion of the Valley and Ridge Province, near the boundary with the Cumberland Plateau. The Valley and Ridge Province, a zone of folded and faulted sedimentary rocks in the Appalachian mountain belt, is characterized by numerous linear ridges and valleys that trend approximately southwest-northeast as shown on Figure 4.6-2. The rocks of the Valley and Ridge Province in eastern Tennessee are Early Cambrian to Early Mississippian in age. A stratigraphic column for the ORR southeast of East Fork Ridge (south of Interstate 95) is shown on Figure 4.6-3. A generalized geologic map of the ORR is shown on Figure 4.6-2. Most of the ORR is underlain by the Rome Formation and Conasauga, Knox, and Chickamauga Groups, sedimentary rocks of Cambrian and Ordovician age (Hatcher et al. 1992). A geologic cross-section of the ORR is shown on Figure 4.6-4.

The Rome Formation consists of interbedded sandstone, siltstone, and shale. The base of the Rome is not exposed in the Oak Ridge area, but consideration of regional structural trends suggests that the Rome Formation is in fault contact with younger rocks. On the Copper Creek and Whiteoak Mountain thrust sheets the Rome is 120-180 meters (390-590 feet) thick, and on



Source: Hatcher et al. 1992.

Figure 4.6-1. Generalized map of the southern Appalachian geologic provinces showing the location of the Oak Ridge Reservation.



Source: MMES 1993a.

Figure 4.6-2. Geologic map of the Oak Ridge Reservation

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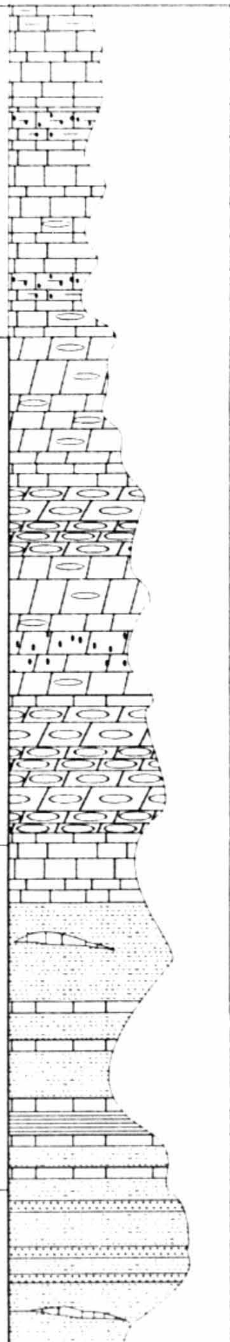
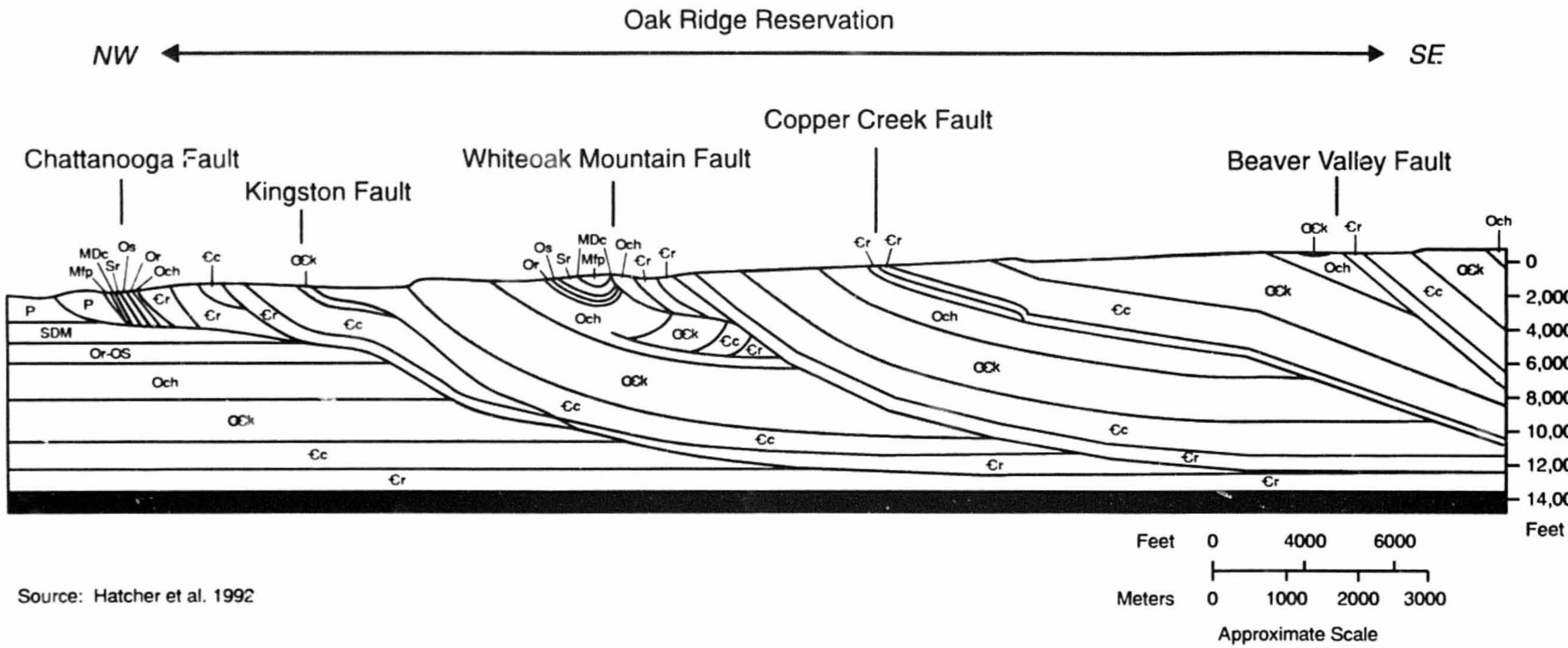


System	Series	Group	Thickness, m		Formation	Hydrologic Unit
ORDOVICIAN	UPPER	Chickamauga Group (OCh)	100-170	Omc	Moccasin Formation	Aquitard
ORDOVICIAN	UPPER	Chickamauga Group (OCh)	105-110	Owi	Witten Formation	Aquitard
ORDOVICIAN	UPPER	Chickamauga Group (OCh)	5-10	Obw	Bowen Formation	Aquitard
ORDOVICIAN	MIDDLE	Chickamauga Group (OCh)	110-115	Obe	Benbolt / Wardell Formation	Aquifer
ORDOVICIAN	MIDDLE	Chickamauga Group (OCh)	80-85	Ork	Rockdell Formation	Aquifer
ORDOVICIAN	MIDDLE	Chickamauga Group (OCh)	75-80	Ofl	Hogskin Member Fleanor Shale Member (Lincolnshire Fm)	Aquitard
ORDOVICIAN	MIDDLE	Chickamauga Group (OCh)	70-80	Oe	Eidson Member (Lincolnshire Fm)	Aquitard
ORDOVICIAN	MIDDLE	Chickamauga Group (OCh)	70-80	Obl	Blackford Formation	Aquitard
ORDOVICIAN	LOWER	Knox Group (OꞒk)	75-150	Oma	Mascot Dolomite	Aquifer
ORDOVICIAN	LOWER	Knox Group (OꞒk)	90-150	Ok	Kingsport Formation	Aquifer
ORDOVICIAN	LOWER	Knox Group (OꞒk)	40-60	Olv	Longview Dolomite	Aquifer
ORDOVICIAN	LOWER	Knox Group (OꞒk)	152-213	Oc	Chepultepec Dolomite	Aquifer
CAMBRIAN	UPPER	Knox Group (OꞒk)	244-335	Ꞓcr	Copper Ridge Dolomite	Aquifer
CAMBRIAN	UPPER	Conasauga Group (Ꞓc)	100-110	Ꞓmn	Maynardville Limestone	Aquifer
CAMBRIAN	UPPER	Conasauga Group (Ꞓc)	150-180	Ꞓn	Nolichucky Shale	Aquitard
CAMBRIAN	MIDDLE	Conasauga Group (Ꞓc)	98-125	Ꞓdg	Dismal Gap Formation (Formerly Maryville Ls.)	Aquitard
CAMBRIAN	MIDDLE	Conasauga Group (Ꞓc)	25-34	Ꞓrg	Rogersville Shale	Aquitard
CAMBRIAN	MIDDLE	Conasauga Group (Ꞓc)	31-37	Ꞓf	Friendship Formation (Fomerly Rutledge Ls.)	Aquitard
CAMBRIAN	LOWER		56-70	Ꞓpv	Pumpkin Valley Shale	Aquitard
CAMBRIAN	LOWER		122-183	Ꞓr	Rome Formation	Aquitard

1 meter = 3.2808 feet

Source: Modified from Hatcher et al. 1992.

Figure 4.6-3. Stratigraphy of the ORR on the Whiteoak Mountain and Copper Creek Thrust Sheets.



Єr = Rome Formation

Єc = Conasauga Group

OЄk = Knox Group

Och = Chickamauga Group (Supergroup)

Or = Reedsville Shale

Os = Sequatchie Formation

Sr = Rockwood Formation

SDM = Silurian, Devonian, and Mississippian Units

MDc = Chattanooga Shale

Mfp = Fort Payne Formation

P = Pennsylvanian Units

Figure 4.6-4. Generalized geologic profile beneath the Oak Ridge Reservation.

the Kingston thrust sheet it is over 450 meters (1,500 feet) thick (Hatcher et al. 1992). Thrust sheets carry the name of the fault at their front, or northwest edge. Faults are shown on Figure 4.6-4. The transition between the sandstones of the Rome Formation and the overlying Pumpkin Valley Shale of the Conasauga Group occurs rather abruptly, as the more resistant sandstones grade into the less resistant shales.

The formations of the Middle to Upper Cambrian Conasauga Group are primarily limy shales interlayered with shales, limestones, and siltstones. At the ORR, the Conasauga Group is divided into six units (see Figure 4.6-3). Approximately 450 meters (1,500 feet) of the Conasauga Group is exposed at the ORR. The transition from the Conasauga Group to the overlying Knox Group is gradational, with the dominant rock type shifting from shale and dolomitic limestones in the Conasauga Group to dolomites with occasional limestones in the Knox Group.

At the ORR, as in the rest of eastern Tennessee, the Upper Cambrian to Lower Ordovician Knox Group is divided into five formations, which are shown on Figure 4.6-3. The Knox Group is approximately 914 meters (3,000 feet) thick on the ORR and consists primarily of thick beds of silty dolomite (Hatcher et al. 1992). Above the Knox Group is the Middle to Upper Ordovician Chickamauga Group. See Figure 4.6-3 for the units that comprise the Chickamauga on the Whiteoak Mountain thrust sheet.

Surface relief at the ORR typically ranges from a ridge crest to valley floor relief of 30 to 69 meters (100 to 225 feet) (Lee and Ketelle 1987). Surface elevations on the ORR range from a maximum of 413 meters (1,356 feet) National Geodetic Vertical Datum at the crest of Melton Hill (see Figure 2.1-2) to a minimum of 226 meters (740 feet) National Geodetic Vertical Datum near Mile 10 on the Clinch River (Boyle et al. 1982). A series of crests and ridges that trend northeast and southwest make up the ORR (Figure 4.6-2). In general, the crests or ridges are composed of resistant sandstone or dolomite beds. Limestone and shale generally form the ridge flanks and valley bottoms.

Sinkholes, large springs, caves, and other karst features are common in the Knox Group, and those parts of the ORR underlain by limestones and dolomites (certain units in the Conasauga, Knox, and Chickamauga Groups) are for the most part classified as karst terranes.

In a karst terrane there is very little surface drainage because of the diversion of surface waters to subterranean (underground) flow routes. These subterranean routes are caves and other enlarged openings that have formed through dissolution of the carbonate rock. Four major karst zones exist at the ORR that appear to be related to distinct stratigraphic horizons (Ketelle 1982). These four karst zones all occur in the Knox Group, specifically in the Copper Ridge Dolomite, near the base of the Chepultepec Dolomite, near the top of the Chepultepec Dolomite, and in the Kingsport Formation (Ketelle 1982). Karst development is also present to varying degrees in the carbonate rocks of the Conasauga Group, most notably in the Maynardville Limestone. In Bear Creek Valley, karst development in the Maynardville Limestone causes variations in discharge along Bear Creek as the surface water and groundwater components vary in dominance (Lee et al. 1988). Bear Creek Valley is underlain by calcareous shale and limestone of the Conasauga Group (Bailey and Lee 1991). Although no site-specific geologic characterization has been conducted at the West Bear Creek Valley site, it appears the proposed SNF management facility is located over the lower Conasauga Group strata not normally characterized by karst development.

The soils occurring in the ORR are predominantly clay, although chert and quartz are also present. Soils developed in the Conasauga are clay. Hatcher et al. (1992) provides detailed information on soils. Many of the soils belong to the broad group of Ultisols, which are reddish or yellowish, moderately acidic soils. Entisols, which are thin surface soils over bedrock that show little development of soil horizons, are found locally in steeply sloping areas. In addition, small areas of inceptisols are found in alluvial areas adjacent to streams (Boyle et al. 1982). These are young soils, also with minimal horizon development. Soils on the ORR tend to retain moisture and are typically 90 percent saturated below a depth of 3 meters (10 feet) (Ketelle and Huff 1984). Depths of soil profiles on the ORR vary from 15 centimeters (6 inches) on slopes to 18 meters (60 feet) over dolomites in the Knox Group (Boyle et al. 1982).

4.6.2 Geologic Resources

The known resources of the geologic units exposed on the ORR are limited to industrial minerals, including quarry rock and clay. These industrial minerals are of low unit value and can be found elsewhere. Quarry rock has been mined at several major locations throughout ORR, but no quarries are currently in operation (Oakes et al. 1984b).

There has been extensive seismic testing by private companies along roads traversing the ORR to explore for deep accumulations of oil and gas. Land has been leased by major oil companies west and northwest of K-25 off the ORR; no exploratory wells have been drilled and the status of oil and gas resources underlying the ORR is unknown at this time (Oakes et al. 1984b).

4.6.3 Seismic and Volcanic Hazards

There is no evidence that there has been volcanic activity in the vicinity of the ORR for more than 1 million years.

4.6.3.1 Historical Seismic Activities. From 1811 to 1975, only five major earthquakes or earthquake series have affected the ORR area. These are the New Madrid, Missouri, earthquake series, and the Charleston, South Carolina; Knoxville, Tennessee; Strawberry Plains, Tennessee; and Kingston, Tennessee earthquakes. The New Madrid earthquake series of December 1811 to February 1812 produced maximum Modified Mercalli Intensity disturbances of V to VI in the ORR area. A Modified Mercalli Intensity V earthquake is felt by everyone. Typical damage includes some dishes, windows, etc. being broken, a few instances of cracked plaster, and unstable objects being overturned. A Modified Mercalli Intensity VI earthquake is also felt by all, and many become frightened and run outdoors. Typical damage includes some heavy furniture moved and a few instances of fallen plaster or damaged chimneys. A Modified Mercalli Intensity of VI is approximately equal to a Richter Magnitude 4.7 (Griggs and Gilchrist 1977).

The 1844 Knoxville earthquake, which occurred approximately 40 kilometers (25 miles) from the ORR, had an epicenter shaking of Modified Mercalli Intensity VI. The Charleston earthquake of 1886 had a Modified Mercalli Intensity of V to VI at the ORR, as did the 1913 Strawberry Plains earthquake. The 1930 Kingston earthquake, 8 kilometers (5 miles) northwest of the ORR, had an epicenter shaking of Modified Mercalli Intensity V (Boyle et al. 1982).

When intensities are reported at epicenters, they would have been less at the ORR, as intensities diminish with distance.

A Modified Mercalli Intensity VII earthquake does not typically cause severe damage, but rather causes breaking of weak chimneys at the roof line, cracks in masonry, and the falling of plaster, loose bricks, and stones. No Modified Mercalli Intensity VII earthquakes have been recorded at the ORR during the 165-year period from 1811 to 1975. Earthquakes with a Modified Mercalli Intensity of VII generally occur one order of magnitude less frequently than earthquakes with a Modified Mercalli Intensity of V to VI. Seismic records indicate that the ORR is located in a region of moderate seismic activity having an average of one to two earthquakes per year, with seismic activity occurring in bursts followed by long periods of no activity. No deformation of recent surface deposits has been detected, and seismic shocks from the surrounding, more seismically active areas are dissipated by distance from the epicenters (Boyle et al. 1982).

The underlying structure of the ORR is complex due to the extensive faulting and deformation characteristic of the region. There are three regional thrust faults in the ORR area, the Kingston, Whiteoak Mountain, and Copper Creek Faults (see Figure 4.6-4). All three strike to the northeast and dip to the southeast. Latest movement on the faults was Late Pennsylvanian/Early Permian (280 to 290 million years ago); consequently, they are not considered to be capable faults at present (Oakes et al. 1984b). According to 10 CFR Part 100, Appendix A, capable faults include those faults that have exhibited movement at or near the ground surface at least once during the past 35,000 years or movement of a recurring nature within the past 500,000 years.

4.6.3.2 Seismicity Studies. Four seismic studies have been specifically conducted for the ORR for which the results have been published. Three of these studies have been summarized by Beavers et al. (1982), and were performed by Blume in 1973, Dames and Moore in 1973, and TERA in 1981. The first two studies were directed toward the seismic hazards at the K-25 Site (formerly the Oak Ridge Gaseous Diffusion Plant), and the latter focused on ORNL (Beavers et al. 1982).

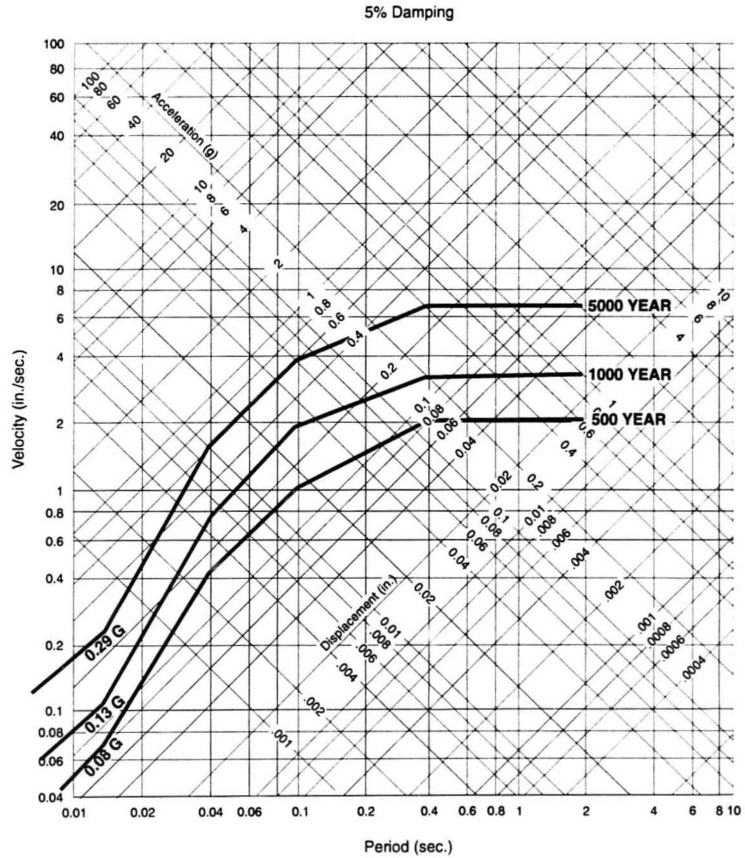
These three early studies presented preliminary analysis and conclusions. The fourth study (McGuire et. al. 1992), is a more recent seismic analysis for the entire ORR. DOE Standards 1020 (DOE 1994a) and 1024 (DOE 1992b) summarize the results of recent seismic analyses at DOE sites and show that the peak ground accelerations for the ORR for 500-year, 1,000-year, 2,000-year and 5,000-year seismic events are 0.08g, 0.13g, 0.19g and 0.29g, respectively.

Figure 4.6-5 presents the site specific uniform hazard response spectra for horizontal rock motion which were approved by DOE Headquarter's Office of Nuclear Energy on August 25, 1993 (Benedict 1993). The response spectra noted on Figure 4.6-5 are for top of rock sites.

4.6.3.3 DOE Seismic Design Criteria. DOE Order 5480.28 requires that the *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards, UCRL-15910* (Kennedy et al. 1990), be used for natural phenomena hazards design and evaluation criteria until a DOE standard is issued. In April 1994, DOE-STD-1020 was issued to replace UCRL-15910.

At the SNF management facility site the categorization of each structure, system and component would be determined in accordance with DOE Standard DOE-STD-1021, *Performance Categorization Criteria for Structures, Systems and Components at DOE facilities Subjected to Natural Phenomena Hazards.*

A maximum horizontal ground surface acceleration of 0.19g at ORR is estimated to result from an earthquake that could occur once every 2,000 years (DOE, 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. DOE orders, standards and site specific procedures require that potential seismic hazards for existing and new facilities be evaluated on a facility specific basis.



Adapted from source: Benedict 1993.

Figure 4.6-5. Oak Ridge - Site Specific Uniform Hazard Response Spectra for Horizontal Rock Motion

4.7 Air Resources

4.7.1 Climatology

Except where indicated, the information presented in this section is derived from Fitzpatrick 1982 and NOAA 1991.

The ORR site is located within the Great Valley of Tennessee in which the Cumberland Plateau borders to the northwest and the Great Smoky Mountains lie to the southeast. Climate at the ORR is influenced by these terrain features.

The climate and meteorology in the lowlands are generally unlike those that occur in the more mountainous regions of the southeastern United States. Daytime winds are usually southwesterly, while night-time winds are northeasterly, at least during periods of light wind. The elevated ridges of the Cumberland Plateau and Great Smoky Mountains encompassing the valley impede wind speeds to a moderate degree. The Cumberland Plateau retards the drainage of cold air from the northwest into the valley during winter, thus reducing the probability of extremely cold temperatures.

The average daily temperature at the Oak Ridge National Weather Service Station, considered representative of the ORR, was 14.2°C (57.5°F) for the period of record 1961-1990. The average daily temperatures varied from a low of 2.6°C (36.7°F) in January to a high of 24.8°C (76.6°F) in July.

Humidity data are maintained at the Knoxville National Weather Service with a period of record from 1961-1990. Records are reported for humidity readings during the hours 0100, 0700, 1300, and 1900 (local time). The 0700 and 1900 values will be reported here. The mean 0700 relative humidity was 86 percent with the mean monthly maximum of 92 percent occurring in July and August, and the mean monthly minimum of 80 percent occurring during February and March. The mean 1900 relative humidity is 63 percent with the mean monthly maximum of 68 percent occurring in September and December, and the mean monthly minimum of 52 percent occurring in April.

The mean wind speed measured at the Oak Ridge National Weather Service over the period 1969 to 1984 was 2.0 meters per second (4.4 miles per hour) at an average height above ground of about 13 meters (41 feet). At a meteorological tower at the ORR the mean wind speed was 2.1 meters per second (4.7 miles per hour) at about 10 meters (33 feet) above ground level. Wind speeds in the ORR area are influenced by local topographic conditions and are generally higher on top of the ridges than in the valleys.

The wind direction above the ridgetops and within the valleys tends to follow the orientation of the valleys. The prevailing wind direction is from the southwest, with a secondary maximum from the northeast during the winter, spring, and summer months. The situation is reversed in the fall.

Figure 4.7-1 shows 1992 wind roses for the 10- and 60-meter levels of the Y-12 west meteorological tower. The annual 10-meter level on the Y-12 west meteorological tower shows peak wind direction frequencies from the west-southwest, with the secondary peak from the northeast. The annual 60-meter level shows wind direction frequencies from the northeast and a secondary peak from the southwest. Since the valley floor is inclined, cold air will drain down the valley during stable periods. Both wind rose levels show the influence of the topography on the wind direction.

Damaging winds are uncommon in the region. Peak gusts recorded in the Great Valley are generally in the 27- to 31-meter-per-second (60- to 70-mile-per-hour) range for the months of January through July; in the 22- to 27-meter-per-second (50- to 60-mile-per-hour) range for August, September, and December; and in the 16- to 20-meter-per-second (35- to 45-mile-per-hour) range in October and November. The maximum gust reported in the region was about 37 meters per second (82 miles per hour); it occurred during the month of March at Chattanooga. Knoxville has reported a peak gust of about 33 meters per second (73 miles per hour) and Oak Ridge a gust of about 26 meters per second (59 miles per hour).

Winter is the wettest of the seasons in the ORR area; March and December are the wettest months and October the driest. The annual average precipitation measured at the ORR in Bethel Valley from 1944 through 1964 was 130.9 centimeters (51.5 inches), while the annual

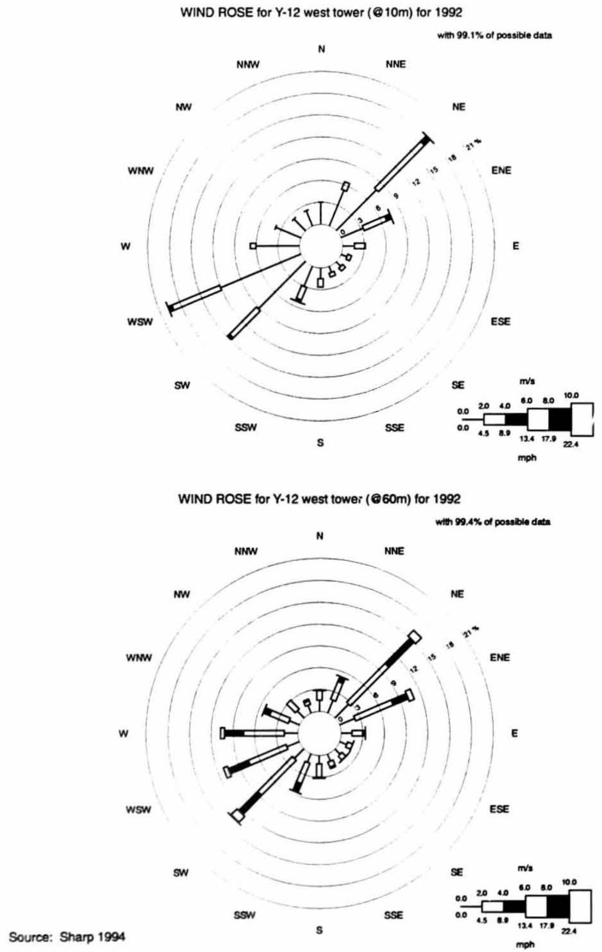


Figure 4.7-1. Wind Roses for Y-12 west tower (@ 10 and 60m) for 1992 at ORR.

average precipitation for the National Weather Service in Oak Ridge from 1961 through 1990 was 137.2 centimeters (54.0 inches). The maximum monthly precipitation was 48.9 centimeters (19.3 inches) in July 1967, while the maximum rainfall in a 24-hour period observed at the Oak Ridge National Weather Service was recorded in August 1960 at 19.0 centimeters (7.5 inches).

On average there are about 51 thunderstorm days per year at the Oak Ridge National Weather Service station. The summer thunderstorms, which may be accompanied by strong winds, heavy precipitation, or, less frequently, hail, occur primarily during the late afternoon and evening hours. Summer thunderstorms are attributable primarily to convective activity resulting from solar heating of the ground and generally moist atmospheric conditions. Thunderstorm activity in the winter months is attributable mainly to frontal activity.

The Great Valley of Tennessee is infrequently subject to tornadoes. The western half of the state has experienced three times as many tornadoes as the eastern half, where the ORR is located. The ORR did experience a tornado from a severe thunderstorm on February 21, 1993 (MMES 1993b). The tornado path passed the Y-12 Plant in an east-northeast direction for approximately 21 kilometers (13 miles), ending just north of Knoxville. The wind speeds associated with this tornado ranged from 18 meters per second (40 miles per hour) to nearly 58 meters per second (130 miles per hour), depending on the location along the path (MMES 1993b).

Hurricanes are rarely sustained once they reach as far inland as the Great Valley due to the rapid loss of energy when they are cut off from their source of moisture. The remnants of nine hurricanes that were classified as devastating after crossing the coastline of the United States have traversed the borders of Tennessee in the last 70 years.

Atmospheric dispersion improves as wind speed increases, conditions become more unstable, and the depth of the mixing height increases. The transport and dispersion of airborne material are direct functions of air movement. Transport directions and speeds are governed by the general patterns of air flow (and by the nature of the terrain), whereas the diffusion of airborne material is governed by small-scale, random eddying of the atmosphere (i.e., turbulence). Turbulence is indicated by atmospheric stability classification. Data collected at

Y-12 for calendar year 1992 were classified using the vertical temperature difference (i.e., between 60- and 10-meter levels) in accordance with Nuclear Regulatory Commission Regulatory Guide 1.23 (NRC 1986). The atmospheric conditions are unstable (i.e., Stability Classes A through C) approximately 5 percent of the time, neutral (Class D) approximately 43 percent of the time, and stable (Classes E through G) approximately 52 percent of the time at the 10-meter level.

4.7.2 Air Monitoring Networks

This section discusses the air monitoring networks of the ORR. Atmospheric emissions from the ORR facilities are monitored by stack monitors and by a network of ambient air monitoring stations on the perimeter of each major ORR operations area (ORNL, the Y-12 Plant, and K-25 Site), as well as on the ORR perimeter and throughout the surrounding communities.

4.7.2.1 Radiological Monitoring Network. Twelve of the ambient air monitoring stations on the perimeter of the Y-12 Plant routinely monitor total suspended uranium particulates. The ORNL perimeter monitoring network consists of four stations that monitor radiation parameters (i.e., gross alpha, gross beta, iodine, and gamma-emitting radionuclides). Samples of atmospheric tritium are also collected monthly at selected perimeter stations.

4.7.2.2 Nonradiological Monitoring Network. The perimeter ambient air monitoring network for K-25, which was upgraded in 1986, consists of five stations that monitor airborne particulate contaminants such as nickel, lead, and chromium. In 1988, two additional ambient air monitoring stations were installed at the K-25 Site. These stations measure polychlorinated biphenyls, furans, dioxins, and hexachlorobenzene that may accidentally be released due to the Toxic Substance Control Act incinerator (located in the K-25 area).

4.7.3 Air Releases

4.7.3.1 Radiological Emissions. Table 4.7-1 presents the radioactive emissions to the atmosphere from each of the three ORR areas (ORNL, K-25, and Y-12) during 1992.

Table 4.7-1. Radioactive atmospheric emissions (curies/yr) from the ORR during 1992.

Isotope	ORNL	K-25	Y-12
Hydrogen-3 (Tritium)	2.14×10^{3}	0.0×10^{0}	0.0×10^{0}
Beryllium-7	8.91×10^{-6}	0.0×10^{0}	0.0×10^{0}
Potassium-40	0.0×10^{0}	1.01×10^{-3}	0.0×10^{0}
Cobalt-57	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Cobalt-60	2.97×10^{-5}	0.0×10^{0}	0.0×10^{0}
Bromine-82	1.02×10^{-5}	0.0×10^{0}	0.0×10^{0}
Krypton-83m	7.32×10^{1}	0.0×10^{0}	0.0×10^{0}
Krypton-85	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Krypton-85m	1.73×10^{2}	0.0×10^{0}	0.0×10^{0}
Krypton-87	3.50×10^{2}	0.0×10^{0}	0.0×10^{0}
Krypton-88	4.94×10^{2}	0.0×10^{0}	0.0×10^{0}
Krypton-89	6.27×10^{2}	0.0×10^{0}	0.0×10^{0}
Strontium-90	1.19×10^{-4}	0.0×10^{0}	0.0×10^{0}
Niobium-95	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Technetium-97	0.0×10^{0}	6.10×10^{-2}	0.0×10^{0}
Ruthenium-106	0.0×10^{0}	4.36×10^{-4}	0.0×10^{0}
Iodine-129	2.70×10^{-4}	0.0×10^{0}	0.0×10^{0}
Iodine-131	1.25×10^{-1}	0.0×10^{0}	0.0×10^{0}
Iodine-132	1.36×10^{0}	0.0×10^{0}	0.0×10^{0}
Iodine-133	6.48×10^{-1}	0.0×10^{0}	0.0×10^{0}
Iodine-134	2.05×10^{-2}	0.0×10^{0}	0.0×10^{0}
Iodine-135	1.22×10^{0}	0.0×10^{0}	0.0×10^{0}
Xenon-133	8.81×10^{2}	0.0×10^{0}	0.0×10^{0}
Xenon-133m	2.74×10	0.0×10^{0}	0.0×10^{0}
Xenon-135	2.82×10	0.0×10^{0}	0.0×10^{0}
Xenon-135m	1.55×10^{2}	0.0×10^{0}	0.0×10^{0}
Xenon-138	8.50×10^{2}	0.0×10^{0}	0.0×10^{0}
Cesium-134	6.03×10^{-7}	0.0×10^{0}	0.0×10^{0}
Cesium-137	6.13×10^{-4}	8.16×10^{-5}	0.0×10^{0}
Cesium-138	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Barium-137	3.84×10^{-4}	0.0×10^{0}	0.0×10^{0}
Barium-137m	6.13×10^{-4}	8.16×10^{-5}	0.0×10^{0}
Barium-140	1.00×10^{-4}	0.0×10^{0}	0.0×10^{0}
Lanthanum-140	1.39×10^{-6}	0.0×10^{0}	0.0×10^{0}

Table 4.7-1. (continued).

Isotope	ORNL	K-25	Y-12
Cerium-144	0.0×10^{0}	1.23×10^{-6}	0.0×10^{0}
Europium-152	1.86×10^{-12}	0.0×10^{0}	0.0×10^{0}
Europium-154	5.87×10^{-6}	0.0×10^{0}	0.0×10^{0}
Europium-155	3.02×10^{-6}	0.0×10^{0}	0.0×10^{0}
Osmium-191	2.27×10^{-2}	0.0×10^{0}	0.0×10^{0}
Gold-194	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Lead-212	1.56×10^{0}	0.0×10^{0}	0.0×10^{0}
Thorium-228	9.52×10^{-6}	1.54×10^{-3}	0.0×10^{0}
Thorium-230	6.49×10^{-7}	7.41×10^{-4}	0.0×10^{0}
Thorium-232	1.86×10^{-7}	2.96×10^{-5}	0.0×10^{0}
Thorium-234	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Protactinium-234m	0.0×10^{0}	4.07×10^{-1}	0.0×10^{0}
Uranium-234	2.24×10^{-5}	2.55×10^{-2}	4.70×10^{-2}
Uranium-235	4.79×10^{-7}	1.12×10^{-3}	1.49×10^{-3}
Uranium-236	0.0×10^{0}	0.0×10^{0}	1.86×10^{-4}
Uranium-238	7.57×10^{-7}	3.74×10^{-2}	4.11×10^{-3}
Neptunium-237	0.0×10^{0}	1.10×10^{-4}	0.0×10^{0}
Plutonium-238	7.40×10^{-6}	6.02×10^{-4}	0.0×10^{0}
Plutonium-239	2.06×10^{-5}	1.12×10^{-4}	0.0×10^{0}
Americium-241	1.37×10^{-5}	0.0×10^{0}	0.0×10^{0}
Curium-244	2.05×10^{-4}	0.0×10^{0}	0.0×10^{0}

4.7.3.2 Nonradiological Emissions. Table 4.7-2 presents the nonradiological emissions to the atmosphere from each of the three ORR areas during 1992.

4.7.4 Air Quality

4.7.4.1 Radiological. A summary of ORR airborne radionuclide emissions for 1992 is presented in Table 4.7-1. The GENII environmental transport and dose assessment model was used to calculate the effective dose equivalent resulting from these radionuclide emissions. These results are summarized in Table 4.7-3. The maximum effective dose equivalent at the ORR boundary is 3.3 millirem. This is 33 percent of the corresponding National Emissions Standard for Hazardous Air Pollutants. The collective effective dose equivalents to the estimated population of 910,000 persons within 80 kilometers (50 miles) of the proposed SNF facility is 52 person-rem. This dose is 0.019 percent of the natural background radiation affecting this population. Background radiation doses are presented in Figure 4.7-2.

4.7.4.2 Nonradiological. The ORR is located in Anderson and Roane Counties, in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region 207. As of 1993, the areas within this Air Quality Control Region were designated as attainment with respect to all National Ambient Air Quality Standards (CFR 1993a).

One Prevention of Significant Deterioration ambient air quality Class I area can be found in the vicinity of ORR. That is the Great Smoky Mountains National Park, located approximately 48 kilometers (30 miles) southeast of ORR. Since the promulgation of the Prevention of Significant Deterioration regulations, no such permits have been required for any emissions source at the ORR.

Ambient air quality within and near the ORR is monitored for total suspended particulates, particulate matter less than 10 microns in diameter (PM_{10}), fluorides, lead, and sulfur dioxide, which was monitored until August 1990 (MMES 1993a). Ambient air quality monitoring data collected at the ORR are summarized in Table 4.7-4.

Table 4.7-2. Nonradiological emissions at ORR (kg/yr).[a]

Pollutant	Y-12	ORNL	K-25
Carbon monoxide	36,807	45,872	12,119
Nitrogen dioxide	648,746	201,090	20,065
Particulates	1,576	5,599	1,137
Sulfur dioxide	268,894	703,419	302
Volatile organic compounds	1,582	1,068	1,011
Chlorine	91	b	1,567
Hydrochloric acid	6,959	b	42
Methanol	26,407	b	b
Nitric acid	9,491	30	b
Perchloroethylene	12,245	b	b
Sulfuric acid	2,424	0	130
Hydrogen fluoride	73	b	b
Mercury	0.01	b	b
Trichloroethane	745	b	b

a. Source: MMES (1993a).

b. No source indicated.

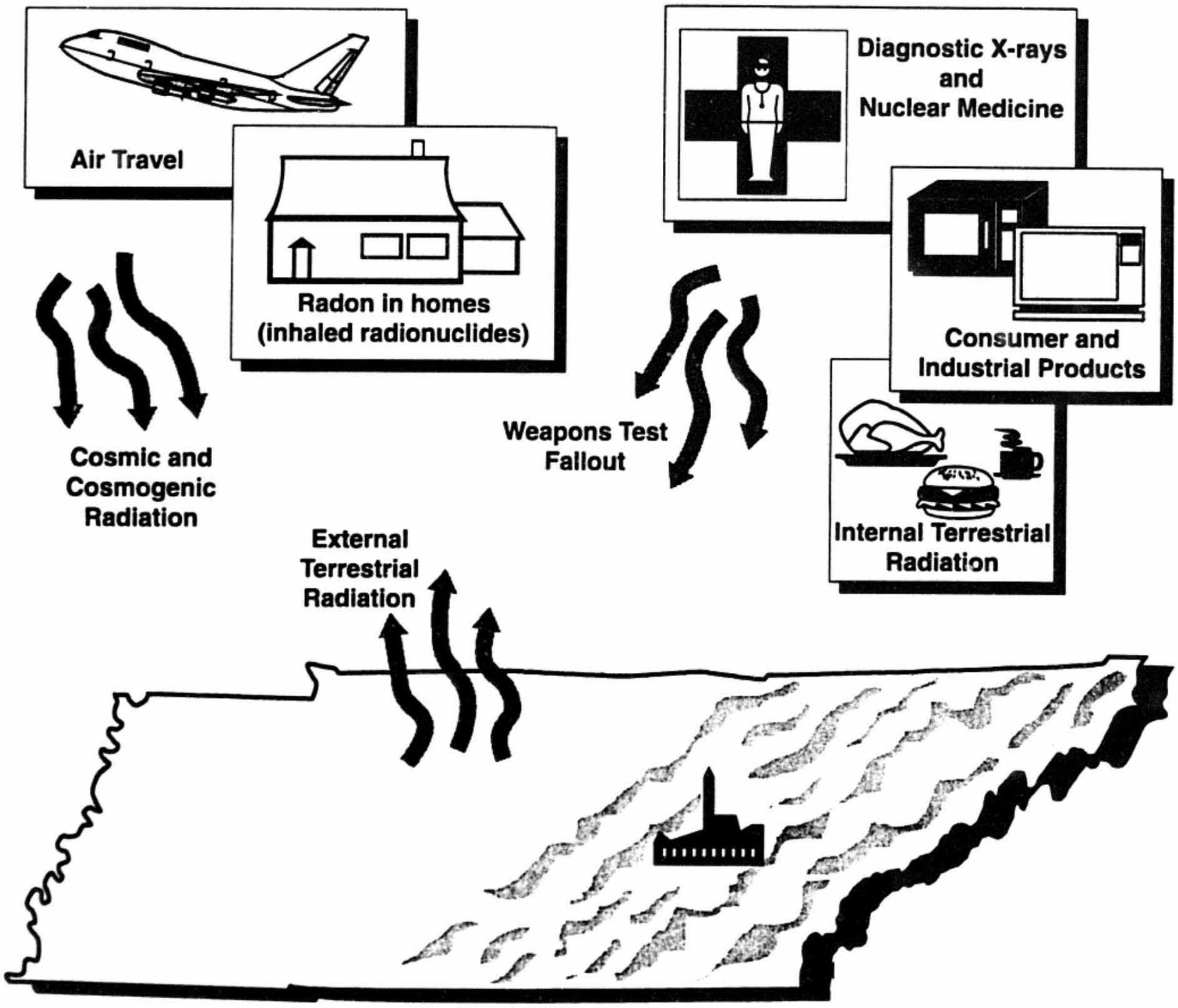
Table 4.7-3. Summary of effective dose equivalents to the public from ORR operations during 1992.[a]

	Maximum exposed individual dose[b]	Collective dose to the population within 80 km of ORR sources[c]
Dose	3.3 mrem	52 person-rem
National Emission Standards for Hazardous Air Pollutan's standard	10 mrem per year	--
Percentage of National Emission Standards for Hazardous Air Pollutants	33	--
Natural background dose	295 mrem per year	279,000 person-rem per year
Percentage of natural background dose	1.1	0.019

a. Sources: MMES (1993a); PNL (1988).

b. The maximum boundary dose is to the hypothetical individual who remains in the open continuously during the year at the ORR boundary.

c. Based on estimated population of 910,000 persons within 80 kilometers of the proposed SNF facility site location in 1995.



Natural Background Radiation[a]	millirem per years[b]
Cosmic and cosmogenic radiation	27
External terrestrial radiation	28
Internal terrestrial radiation	40
Radon in homes (inhaled)	200
Other Background Radiation[a]	
Diagnostic X-rays and nuclear medicine	53
Weapons test fallout	<1
Air travel	1
Consumer and industrial products	10
Total	371

[a] From EPA 1981; NCRP 1987; Value for radon is an average for the United States.
[b] Committed effective dose equivalent.

Figure 4.7-2. Sources of radiation exposure, unrelated to Oak Ridge Reservation operations, to individuals in the vicinity of ORR.

Table 4.7-4. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at the ORR.

Criteria pollutant	Averaging time	Most stringent regulation or guideline ($\mu g/m^3$)	Maximum[a] background concentration ($\mu g/m^3$)	Maximum existing site contribution ($\mu g/m^3$)	Total existing maximum concentration ($\mu g/m^3$)
Carbon monoxide	8-hour	10,000	b	6.9	6.9
	1-hour	40,000	b	24.1	24.1
Nitrogen dioxide	Annual	100	b	2.1	2.1
Lead	Calendar quarter	1.5	b	c	c
Particulate matter less than 10 microns in diameter	Annual	50	8	4.0[d]	12.0
	24-hour	150	54	43.9[d]	97.9
Sulfur dioxide	Annual	80	27	2.3	29.3
	24-hour	365	146	31.8	177.8
	3-hour	1,300	321	80.5	401.5
Total suspended particulates[f]	Annual	50	32	4.0	36.0
	24-hour	150	73	43.9	116.9
Hydrogen Fluoride	30-day	1.2	0.06	c	0.06
	7-day	1.6	0.03	c	0.03
Hydrogen fluorides (as fluorides)	24-hour	2.9	b	c	c
	8-hour	3.7	b	c	c
Hazardous[e] air pollutants					
Chlorine	8-hour	150	b	0	c
Selenium	8-hour	20	b	c	c
Mercury	8-hour	0.5	b	c	c
Chromium	8-hour	5	b	c	c
Chrome	8-hour	5	b	c	c

a. Ambient air quality data (MMES 1992a, 1991a).

b. Not monitored.

c. Not estimated because the potential release is negligible.

d. It is conservatively assumed that data for particulate matter less than 10 microns in diameter (PM_{10}) are total suspended particulates data.

e. State standard.

f. State guideline.

Table 4.7-4 presents the effects of site emissions on local ambient air quality. Concentrations of pollutants obtained from ambient air quality monitoring data are added to pollutant concentrations determined from air dispersion modeling using site-specific emission rates. The resulting sum is used to compare total concentrations to applicable Federal and state criteria pollutant and hazardous/toxic air pollutant guidelines and regulations. All pollutant concentrations of existing emissions at the ORR are below applicable regulations.

4.8 Water Resources

4.8.1 Surface Water

The hydrologic system on the ORR is controlled by the Clinch River (MMES 1994a). The Clinch River flows about 350 miles (560 kilometers) from its headwaters in southwest Virginia, near Tazewell, to its confluence with the Tennessee River at Kingston, Tennessee. Its drainage area is about 4,410 square miles (11,340 square kilometers) (Boyle et al. 1982). All water that drains from the ORR enters the Clinch River and subsequently the Tennessee River.

Flow in the Clinch-Tennessee River system is regulated by multipurpose dams of the Tennessee Valley Authority (TVA). Three dams operated by the TVA control the flow of the Clinch River. Norris Dam, approximately 31 miles (50 kilometers) upstream of the ORR, was constructed to provide flood control and low-flow regulation. Melton Hill Dam, south of the ORNL site, controls the flow of the Clinch River near the ORR. Its primary function is power generation. Flood control is a secondary function. Watts Bar Dam, also used for power generation, is located on the Tennessee River and influences the lower reaches of the Clinch River by creating backwaters that can extend as far upstream as Melton Hill Dam (Oakes et al. 1987).

Heavy precipitation in the area causes localized flooding, primarily in the City of Oak Ridge (MMES 1994a) and along the Clinch River. A flood analysis was prepared by the TVA for the ORR (TVA 1991). This analysis provides flood elevations for flooding events in the Clinch River and major tributaries on the ORR. Flooding events analyzed ranged from the 25-year flood (a flood with a 1 in 25 chance of being equaled or exceeded in any given year) to probable

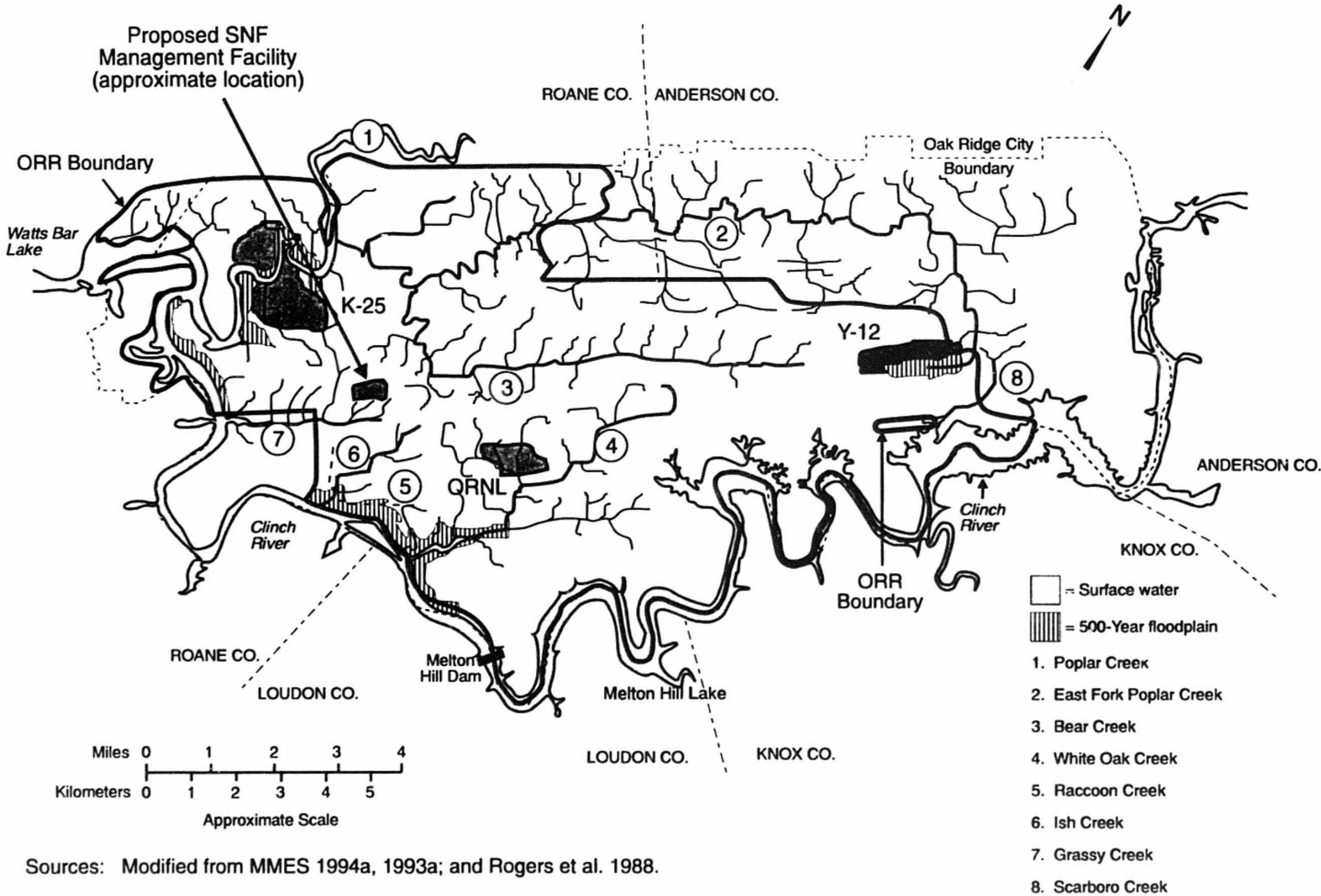
maximum flooding events. Approximate 500-year floodplains (1 in 500 chance in any given year) are shown on Figure 4.8-1. Site-specific surveys should be performed to more accurately determine locations of flooding elevations.

The average discharge from Melton Hill Dam between 1963 and 1979 was 5,300 cubic feet (150 cubic meters) per second (Boyle et al. 1982). The average summer (June-September) discharge for the same period was 4,730 cubic feet (134 cubic meters) per second. However, power is generated at Melton Hill Dam to help meet peak loads and, as a result, flow in the Clinch River is pulsed. Periods of no flow at the dam can be followed by periods of flow of up to 20,000 cubic feet (560 cubic meters) per second. Variations in the flow of the Clinch River affect the flow of the tributaries on the ORR. For example, during peak periods of power generation at Melton Hill Dam, flow from White Oak Creek can be blocked or even reversed. The 1992 minimum monthly release at the Melton Hill Dam occurred in May and was 3.5 billion cubic feet (100 million cubic meters) (MMES 1994a).

The ORR is drained by a network of tributaries of the Clinch River (Figure 4.8-1). A statewide stream classification system based on water quality, water use, and resident aquatic biota designates most streams on the ORR for fish and aquatic life, irrigation, and livestock watering (MMES 1992a). For each designated classification, specific water quality criteria are applied, forming the basis for facility-specific National Pollutant Discharge Elimination System permits. No rivers designated as wild and scenic occur on the ORR.

Stream flow on the ORR varies primarily with seasonal precipitation (MMES 1994a). Precipitation varies throughout the year, with the winter months and July experiencing the highest rainfall. Five-year cycles of wet and dry seasons are also evident. Precipitation is lost through evaporation, vegetation uptake, runoff to streams, and to groundwater recharge through the soil.

The drainage pattern on the ORR is a weakly developed "trellis" pattern (Lee and Ketelle 1987). The majority of the small streams are located in the northeast-southwest-trending valleys. Some streams flow across the ridges through water gaps that may have formed due to the presence of structural features (Golder Associates 1988). Karst topography also affects the



Sources: Modified from MMES 1994a, 1993a; and Rogers et al. 1988.

Figure 4.8-1. Locations of the Clinch River and tributaries on the Oak Ridge Reservation.

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appearance of surface drainage patterns, primarily because of the presence of sinkholes in areas underlain by the Knox Group.

A number of wetlands occur on the ORR (MMES 1994a). Wetlands are surface features periodically saturated with or covered by water, and have hydric soils and hydrophytic plants. With regards to water resources issues, wetlands absorb flood waters and improve groundwater quality. Characteristic wetlands of the ORR region include forested wetlands along creeks, wet meadows and marshes associated with streams and seeps, and emergent communities in shallow embayments and ponds.

The abundance of limestone and dolomite is reflected by the presence of calcium bicarbonate in the surface waters at the ORR. Water hardness is typically moderate, and the concentrations of total dissolved solids normally range between 100 and 250 milligrams per liter (Rogers et al. 1988).

Measurements of surface water quality and flow are made at a number of sampling stations on and around the ORR. Reference surface waters, ORR surface waters receiving effluents, off-reservation surface waters, and effluents are all sampled and analyzed as part of the surface water monitoring program. Water samples are collected and analyzed for radiological and nonradiological content, and the results are reported yearly in publicly available environmental reports (e.g., MMES 1993a; 1992a; 1991a).

Although bedrock characteristics differ somewhat among the watersheds of these streams, most of the observed differences in water quality are attributed to different contaminant loadings (Rogers et al. 1988). Both wastewater discharges and the groundwater transport of contaminants from waste disposal sites affect water quality in ORR streams. Consequently, a number of surface streams have been contaminated by activities at the ORR (DOE 1992c). In the past, contaminants have been directly released to surface waters on the ORR. Indirect releases via shallow groundwater discharge to surface water streams have occurred in the past and continue to date. For example, activities at the ORNL have contaminated reaches of the White Oak Creek system and Melton Branch with radionuclides, metals, and other hazardous chemicals. The stream channel of Upper East Fork Poplar Creek in the Y-12 Plant area has been contaminated from past activities at the Y-12 Plant. Activities at the Y-12 Plant have also contaminated surface water and groundwater in the Bear Creek Valley with nitrates, volatile organics, radionuclides, and metals beyond the ORR boundary. Operations at the Y-12 Plant have also contaminated Lower East Fork Poplar Creek beyond the ORR boundary with mercury, other metals, organics, and radionuclides. Ultimately, contaminants from all these streams have been discharged to the Clinch River, where sediment contamination is a primary concern.

All effluent discharges to streams are required to meet specified National Pollution Discharge Elimination System permit limits (MMES 1994a). For example, the quality of water in East Fork Poplar Creek partially reflects the influence of the Y-12 Plant and the City of Oak Ridge municipal wastewater treatment facility. Each of the ORR installations has a National Pollution Discharge Elimination System permit. In 1992, more than 400 National Pollution Discharge Elimination System stations were sampled, requiring more than 65,000 water analyses. Significant reductions in the number of noncompliances for the ORR between 1991 to 1992 were engineered especially with respect to the Y-12 Plant. The K-25 Site was in 99.9 percent compliance with discharge limits. The Y-12 Plant was in 99.5 percent compliance with discharge limits. The ORNL was in 99 percent compliance with discharge limits. Table 4.8-1 lists the National Pollution Discharge Elimination System noncompliances by installation and discharge point. At the Y-12 Plant, ORNL, and the K-25 Site, radiological effluents were well within limits at all effluent monitoring locations (MMES 1993a).

Water quality in the Clinch River is affected by ORR activities, by contaminants introduced upstream from the ORR, and by flow regulation at the Tennessee Valley Authority dams. Stream impoundment has resulted in a rise in water temperatures, sediment retention, and contaminant adsorption. Several institutions routinely monitor water quality in the Clinch River. Both the Tennessee Valley Authority and the U.S. Geological Survey monitor just below Melton Hill Dam. The Tennessee Department of Environment and Conservation maintains a monitoring station on the Clinch River about 2 miles (3.2 kilometers) below the mouth of Poplar Creek and the K-25 Site (Rogers et al. 1988).

The Clinch River supplies most of the water to the ORR, the City of Oak Ridge, and other cities along the river (MMES 1994a). Major surface water uses in the Oak Ridge area include

Table 4.8-1. 1992 National Pollutant Discharge Elimination System noncompliance at the ORR.[a]

Installation	Discharge point	Parameter	Percent compliance	Number of samples
Y-12	302 (Rogers Quarry)	pH	99	53
	501 (Central Pollution Control Facility [CPCF-1])	Total toxic organics	91	23
	502 (West End Treatment Facility)	Total suspended solids	98	54
	503 (Steam Plant Wastewater Treatment Facility)	Iron, total	99	158
		Oil and grease	99	157
	Category IV outfalls (untreated process wastewaters)	pH	95	107
	506 (9204-3 sump pump oil)	Oil and grease	98	53
		pH	98	53
	512 (Groundwater Treatment Facility)	Polychlorinated biphenyls	97	37
	Creek Outfalls	Visual	not applicable	22[a]
ORNL	X01 (Sewage Treatment Plant)	Oil and grease	99	157
		Total suspended solids	96	157
	X02 (Coal Yard Runoff Treatment Facility)	Oil and grease	94	34
	Category I outfalls	Oil and grease	33	3
	Category II outfalls	Oil and grease	87	166
		Total suspended solids	91	166
	Cooling systems	Chlorine, total residual	98	45
		Copper, total	98	45
		Zinc, total	98	45
K-25	001 (K-1700 discharge)	Aluminum	96	not available (4)[b]
		Oil and grease	99	not available (1)[b]
	005 (K-1203 sanitary treatment facility)	Chlorine, residual	99	not available (1)[b]
		Fecal coliform, No./100 milliliter	99	not available (2)[b]
		Settleable solids, milliliter/liter	99	not available (1)[b]
	006 (K-1007-B holding pond)	Chemical Oxygen Demand	99	not available (1)[b]
	007 (K-901-A holding pond)	Chromium, total	98	not available (1)[b]
		Suspended solids	98	not available (2)[b]
		Dissolved oxygen	98	not available (6)[b]
	Storm drain	Unpermitted discharge	not applicable	4[b]

a. Source: MMES (1993a).

b. Number of noncompliances.

withdrawals for industrial and public water supplies, commercial and recreational navigation, and other recreational activities such as fishing, boating, and swimming. Five public water supplies are located downstream of the ORR (MMES 1994a). The two nearest are the K-25 Site water treatment plant and the Kingston water treatment plant. These are located 2.5 miles (4 kilometers) above and 21 miles (34 kilometers) below the mouth of Poplar Creek, respectively.

4.8.2 Groundwater

Groundwater beneath the ORR is heavily influenced by the site geologic structure (Solomon et al. 1992). Geologic units of the ORR are assigned to two broad hydrologic groups: (1) the Knox aquifer, formed by the Knox Group and the Maynardville Limestone (carbonate rocks), in which flow is dominated by solution conduits and which stores and transmits relatively large volumes of water; and (2) the ORR aquitards, made up of all other geologic units of the ORR (sandstones, siltstones, and shales), in which flow is controlled by fractures. These aquitards may store fairly large volumes of water, but they transmit only limited amounts.

The hydrologic groups are divided into the near-surface stormflow zone, the vadose zone, the groundwater zone, and the aquiclude (Solomon et al. 1992). Flow in the 3- to 7-foot-deep (1- to 2-meter) deep stormflow zone accounts for approximately 90 percent of the water moving laterally through the subsurface. The stormflow zone can transmit some water laterally to surface streams at approximately 39 feet (12 meters) per hour through large pores; however, less than 1 percent of the total void volume of the zone is large pores. Most water mass resides and migrates through smaller pores in the stormwater zone at rates 10 to 100 times slower. Advective-diffusive exchange between pores substantially reduces contaminant migration rates. A vadose zone between the stormflow and groundwater zones exists at the ORR except where the water table is at the land surface, such as along perennial stream channels. The vadose zone is thickest beneath ridges and thinnest or non-existent in valleys. Most groundwater movement through the vadose zone occurs vertically during precipitation events and occurs along discrete features such as fractures in the bedrock. Measurements of permeability, recharge, and conductivity vary considerably by locality in the vadose zone. Generally, conductivity is less than an inch (on the order of millimeters to centimeters) per day. The groundwater zone is the

continuously saturated area in which the remaining 10 percent of lateral sub-surface water movement occurs. Very little water movement occurs in the deep aquiclude layer.

The Knox aquifer is the only true aquifer of the ORR and is the primary source of sustained natural flow in perennial streams such as Upper White Oak Creek, East Fork Poplar Creek, and Bear Creek (Solomon et al. 1992). In some places the Knox aquifer can supply large quantities of water to wells. Flow volumes are significantly larger than in the aquitards, and flow paths are deeper. The potential groundwater flow path length in the Knox aquifer is also substantially greater than in the aquitards--on the order of a few miles or kilometers. The one strongly suspected instance of groundwater flow across the ORR boundary occurs along the northeastern portion of Chestnut Ridge, where water in the Knox aquifer travels along a geological strike northeastward from the Y-12 Plant accross the ORR boundary. In March 1994, DOE announced that elevated levels of four industrial solvents (carbon tetrachloride, chloroform, tetrachloroethylene, and trichloroethylene) had been found in groundwater wells in the Knox aquifer, 2,500 feet east of the Y-12 Plant in the Union Vally Industrial Park (Bowdle 1994). The same solvents are found in groundwater monitoring wells at the Y-12 Plant. DOE is currently investigating the size and direction of the solvent plume. No proposed SNF management facilities would be sited in areas overlying the Knox aquifer.

Virtually all mobile water in the aquitards is discharged to local streams within the ORR. Flow in the ORR aquitards is shallow; about 98 percent occurs at depths of less than 100 feet (30 meters) (Solomon et al. 1992). Water in the aquitards travels through the uppermost part of the groundwater zone along flow paths of up to 1,000 feet (300 meters) in length before being discharged to local surface waters. Groundwater flow volume decreases and solute residence times increase sharply with depth. Mean solute transport rate in the stormflow zone is on the order of meters per hour, but in the intermediate and deep intervals of the groundwater zone, representative transport rates are as low as a few centimeters per year. Additionally, the mobility of most contaminants on the ORR is greatly reduced by sorption onto subsurface solids. Residence times of solutes near the water table in the aquitards range from a few days to a few years. In the intermediate and deep intervals, estimates of residence times range from hundreds to tens of thousands of years. Most groundwater flow in the aquitards occurs through a few widely spaced (23-164 feet [7-50 meters]) permeable regions.

Water in the aquitards is at best a marginal resource (Solomon et al. 1992). A typical well yields under 0.25 gallon per minute (0.02 liter per second). In many places, wells are incapable of producing enough water to support a typical household.

Background groundwater quality at the ORR is generally good in the surficial aquifer zones and poor (because of high total dissolved solids) in the bedrock aquifer at depths greater than 1,000 feet (300 meters) (DOE 1993a). Water in the surficial aquifer is typically a nearly neutral to moderately alkaline calcium bicarbonate type. Transport processes in the subsurface (including diffusion from fractures to the rock matrix, sorption, and exchange) have resulted in an accumulation of contaminants downgradient of the sources (Solomon et al. 1992).

Contaminated sites in need of environmental restoration include past-practice waste disposal sites, waste storage tanks, spill sites, and contaminated inactive facilities (DOE 1993a). Principal groundwater contaminants that exceed applicable standards at the Y-12 Plant include volatile organics, nitrates, heavy metals, and radioactivity (MMES 1993a). Exact rates and extent of the contamination have not been quantified. However, data indicate that most contamination remains relatively close to the source. As an example of the maximum extent of groundwater contamination, nitrate has been detected in wells 3,000 feet (920 meters) southwest of the source. Nitrate is relatively mobile in groundwater and may therefore define the maximum horizontal migration of contamination. At the ORNL, 20 waste area groupings have been identified and are being monitored for groundwater contamination. Monitoring data from each waste area group will direct further groundwater studies. At the K-25 Site, organics are the most commonly detected groundwater contaminants. Elevated levels of gross alpha and gross beta have also been detected in a number of wells. Uranium and technetium-99, respectively, appear to be primarily responsible for the elevated gross alpha and gross beta levels. The metals chromium, lead, arsenic, and barium have been detected in a number of wells at concentrations exceeding drinking water standards. Elevated levels of fluoride and polychlorinated biphenyls have also been detected in some wells.

In 1989, the Oak Ridge National Laboratory implemented an off-site residential drinking water quality monitoring program (MMES 1993a). The program objective is to document groundwater quality near the ORR and to monitor the potential impact of ORR operations on

groundwater quality. Parameters monitored under the program include volatile organics, metals, anions, and various radioactive parameters. Radionuclides and organics have been detected in some of the off-site monitoring wells, however, concentrations have been below drinking water standards. Fluoride has been detected at concentrations exceeding drinking water standards in one of the off-site wells. The high fluoride concentrations and accompanying high pH are most likely attributed to natural chemical reactions in the substrate. No sources or flow paths have been identified for the other constituents detected.

Although surface water sources provide the main portion of potable water supplies in the area, groundwater does provide for some domestic, municipal, farm, irrigation, and industrial use (MMES 1993a). Single-family wells are common in areas not served by public water supplies (MMES 1992a). However, because of the abundance of surface water and its proximity to the points of use, almost no groundwater is used at the ORR (DOE 1993a). Only one supply well exists on the reservation; it provides a supplemental supply to an aquatics laboratory.

All aquifers at the ORR are classified as Class II (DOE 1993a). Class II groundwaters are current and potential sources of drinking water and those waters having other beneficial uses. There are no sole-source aquifers beneath the ORR (DOE 1993a). Water rights are not an issue in the region.

4.9 Ecological Resources

Land for the ORR was primarily in agricultural use at the time of acquisition by the DOE's predecessor agencies. Clearings for orchards and pastures were on some of the upper slopes, rocky areas, and ridgetops; tillage crops were raised on the lower slopes and bottomland. Severe soil erosion also occurred in some areas. Except on very steep slopes, most of the forests had been cut for timber, though not necessarily cleared for agricultural uses. Natural plant communities have since reestablished themselves on most of the ORR, although many areas are maintained as pine plantations or nonforested areas (ORNL 1988). Plant communities at the ORR are characteristic of the intermountain regions of central and southern Appalachia. Approximately 10 percent of the ORR has been developed since it was withdrawn from public access; the remainder of the site has reverted to or been planted with natural vegetation (MMES 1989).

Biotic media, such as fish and deer, that may be affected by the releases or that might provide pathways of exposure to people are included in the environmental surveillance programs at the ORR. Bluegill (*Lepomis macrochirus*) and whitetail deer (*Odocoileus virginianus*) are routinely analyzed for radionuclide contamination. In 1992, the maximum doses to man projected from actual measurements were within the applicable regulatory requirements (see Section 4.12.4 and 4.12.5) (MMES 1993a).

The following describes biotic resources at the ORR, including terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. Within each biotic resource area, the discussion focuses first on the ORR as a whole and then on the proposed site.

4.9.1 Terrestrial Resources

The vegetation of the ORR has been categorized into seven plant communities (Figure 4.9-1) (Parr and Pounds 1987). The pine and pine-hardwood forest is one of the most extensive plant communities on the ORR. Important species of this community type include loblolly pine (*Pinus taeda*), shortleaf pine (*Pinus echinata*), and Virginia pine (*Pinus virginiana*) (Parr and Pounds 1987). Another abundant plant community is the oak-hickory forest, which is commonly found on ridges throughout the ORR. Northern hardwood forest and hemlock-white pine-hardwood forest are the rarest plant community types on the ORR. Currently, timber on the ORR is managed by thinning young stands and harvesting mature stands. Timber is also sold when an area is to be cleared for development (Bradburn 1994). A total of 899 species, subspecies, and varieties of plants have been identified on the ORR (Mann et al. 1985; Cunningham and Pounds 1991).

Thirty areas on the ORR that are representative of the vegetational communities of the southern Appalachian region or that possess unique biotic features have been designated by DOE as National Environmental Research Park Reference Areas (Pounds et al. 1993). Several of these areas are wetlands.

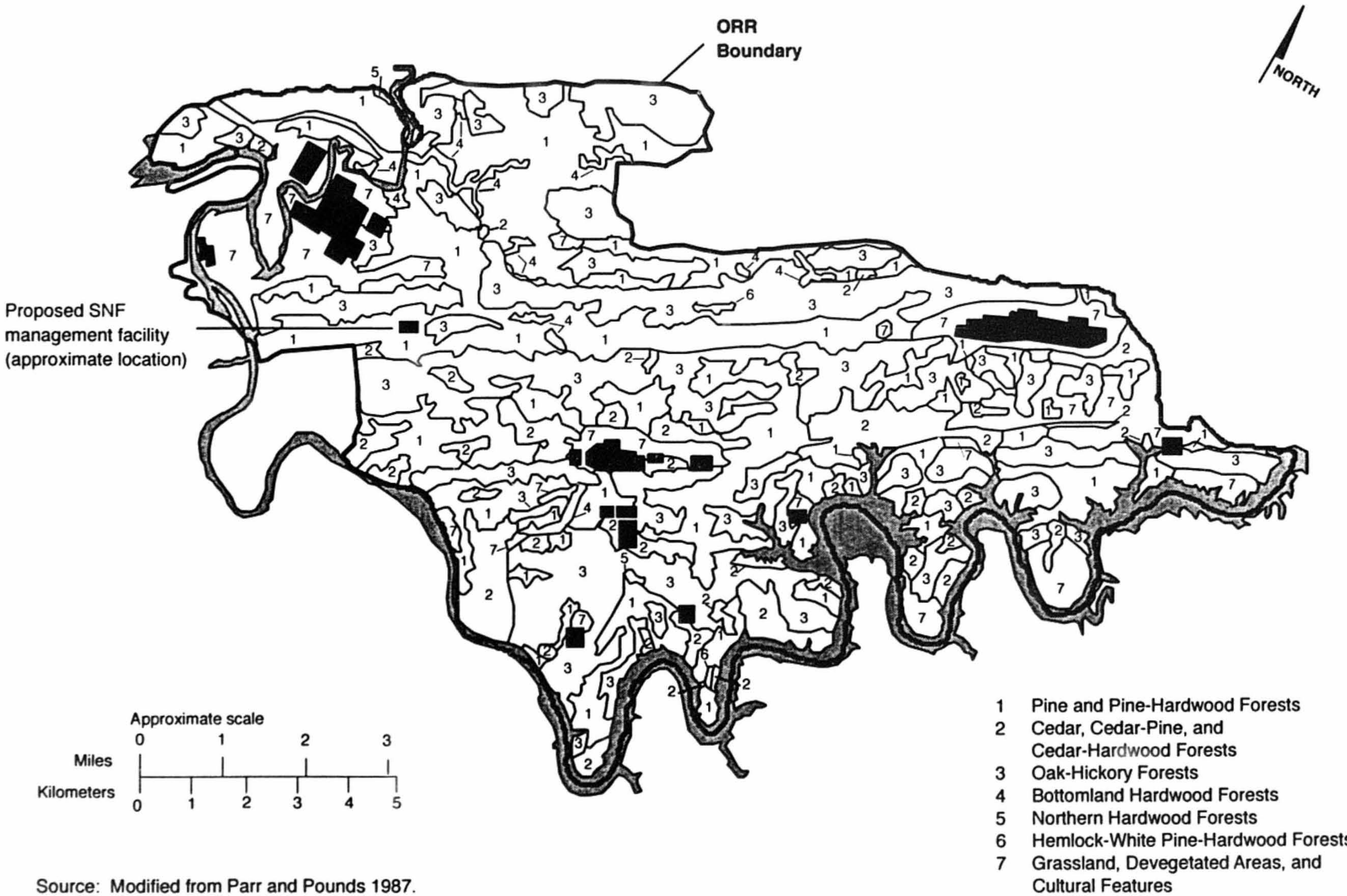


Figure 4.9-1. Oak Ridge Reservation plant communities.

The ORR provides habitat for a large number of animal species. Twenty-six species of amphibians, 33 species of reptiles, 169 species of birds, and 39 species of mammals have been recorded (Parr and Evans 1992). Habitats dominated by hardwood trees support the greatest number of wildlife species, followed in order by wetlands, old fields, and pine plantations (ORNL 1988).

Game animals present on the ORR include the whitetail deer, which has been hunted on the reservation since 1985 (MMES 1992b). Animals commonly found on the ORR include the American toad (*Bufo americanus*), eastern garter snake (*Thamnophis sirtalis*), Carolina chickadee (*Parus carolinensis*), northern cardinal (*Cardinalis cardinalis*), white-footed mouse (*Peromyscus leucopus*), and raccoon (*Procyon lotor*). Raptors, such as the red-shouldered hawk (*Buteo lineatus*) and great horned owl (*Bubo virginianus*), and carnivores, such as the gray fox (*Urocyon cinereoargenteus*) and mink (*Mustela vison*), are ecologically important groups on the ORR (Loar et al. 1981).

The surrounding countryside has much greater proportions of cultivated fields, pastures, and residential areas than the ORR, and much more fragmented forest cover. Because of the greater continuity of forests and a lack of human disturbance over much of the ORR, wildlife species that are affected by forest fragmentation offsite may find an abundance of suitable habitat on the ORR. Thus, the ORR may serve as a refuge for wildlife and as a source of wildlife migration (ORNL 1988).

Vegetative communities of the West Bear Creek site are typical of the ORR as a whole, composed of second-growth oak-hickory forest and mixed pine-hardwood forest. There are some loblolly pine plantations adjacent to the northern edge of the powerline right-of-way and between the right-of-way and Bear Creek Road (Rosensteel 1994). There are no National Environmental Research Park Reference Areas on the SNF site. Fauna of the site would also be similar to those expected throughout the ORR.

4.9.2 Wetlands

Wetlands on ORR have recently been evaluated based on National Wetland Inventory maps and field surveys of vegetation (Cunningham and Pounds 1991). Soils and hydrology were not specifically considered in this survey. Wetlands on the ORR include emergent, scrub/shrub, and forested wetland located in embayments of the Melton Hill and Watts Bar Reservoirs that border ORR; along all the major streams, including East Fork Poplar Creek, Poplar Creek, Bear Creek, and their tributaries; in old farm ponds; and around groundwater seeps.

Several well-developed emergent communities greater than 1 acre (0.004 square-kilometers) occur in shallow embayments of the reservoirs. The emergent communities typically grade into marshy areas adjoining forested wetlands. Most forested wetland sites are typically less than 1 acre, although forested wetlands greater than 1 acre are found along the East Fork Poplar Creek and the Clinch River near Gallahar Bridge. Ponds on the ORR vary in size and support diverse flora and fauna. Other wetland areas exist along utility rights-of-way, especially in Bear Creek and Melton Valleys (Cunningham and Pounds 1991).

Originating on the lower slopes of Pine Ridge are several headwater tributary systems of Grassy Creek that flow from north to south across the West Bear Creek site. The stream valleys contain forested wetlands. A powerline right-of-way crosses the stream bottoms, where the vegetation is dominated by wetland scrubs and herbaceous species, of which a portion adjacent to the west boundary has been designated a National Environmental Research Park Natural Area for the protection of state-listed rare plant species.

4.9.3 Aquatic Ecology

Aquatic habitats on or adjacent to the ORR range from small, free-flowing streams in undisturbed watersheds to larger streams with altered flow patterns because of dam construction. These aquatic habitats include tailwaters, impoundments, reservoir embayments, and large and small perennial streams.

Sixty-four fish species have been collected on or adjacent to the ORR. The minnow family has the largest number of species and is numerically dominant in most streams (ORNL 1988). Representative fish species of the Clinch River in the vicinity of the ORR are shad (*Dorosoma sp.*), herring (*Alosa sp.*), common carp (*Cyprinus carpio*), catfish (*Ictalurus sp.*), bluegill, crappie (*Pomoxis sp.*), and drum (*Aplodinotus sp.*) (Loar et al. 1981). Important fish species taken commercially in the ORR area are common carp and catfish. Recreational species include crappie, bass (*Micropterus sp.*), sauger (*Stizostedion canadense*), sunfish (*Lepomis sp.*), and catfish (Rector 1994).

Results from the ORNL monitoring program indicate varying degrees of impact on the benthic communities of the small perennial streams resulting from past waste disposal practices. Portions of these streams are dominated by pollutant-tolerant insect species (Loar 1992).

Portions of certain streams on the ORR have been designated by DOE as National Environmental Research Park Aquatic Natural or Reference Areas. These areas generally represent nonimpacted streams or reaches of streams and are used primarily for reference areas as part of the biological monitoring and abatement programs or environmental remediation efforts at ORR facilities. There are presently eight Aquatic Natural Areas and nine Aquatic Reference Areas (Pounds et al. 1993). Many of the Aquatic Natural Area streams contain the Tennessee dace, a species listed as in need of management by the State of Tennessee.

The aquatic resources occurring in the area of the West Bear Creek site are limited to several headwater tributary systems of Grassy Creek originating on the lower slopes of Pine Ridge and flowing from north to south across or adjacent to the site. Fifteen fish species have been recorded in Grassy Creek.

A National Environmental Research Park Aquatic Reference Area is located along Grassy Creek and its tributaries, one of which runs through the eastern portion of the proposed site. Grassy Creek has a diverse assemblage of invertebrates and fish species for a stream its size. The ORR uses Grassy Creek as a reference area for studies of other streams affected by site development (Pounds et al. 1993).

4.9.4 Threatened and Endangered Species

Federally and state-listed threatened, endangered, or other special-status species designated by the Endangered Species Act and/or the state's Nongame and Endangered Species and the Rare Plant Protection and Conservation Laws that have a reasonable potential for occurrence on the ORR are listed in Table 4.9-1. The table indicates that 25 of these species have recent records of occurrence on the ORR. The potential occurrence of the other 22 species listed is due to historical record, proximity to geographic ranges, and migratory nature of species. No critical habitat for threatened and endangered species, as defined in the Endangered Species Act (U.S. DOI 1992), exists on the ORR.

Although not all of the ORR has been surveyed for rare species, 33 different areas harboring rare plant species (federally or state-listed) have been designated as National Environmental Research Park Natural Areas by DOE (Pounds et al. 1993). The plant species listed in Table 4.9-1 are scattered among these Natural Areas but are not excluded from other areas on ORR. These Natural Areas are designated to provide protection for rare plant and animal species. The designated areas include river and creek bluffs, calcareous barrens, mesic forests, flood plains, and wetland cover classes.

No animal species listed by the Federal Government as threatened or endangered are known to reside on the ORR (Kroodsma 1987). The bald eagle (Federal, endangered) is a winter visitor to Watts Bar Lake and Melton Hill Lake. None of the species listed in Table 4.9-1 have been recorded on the proposed West Bear Creek Valley site. The purple fringeless orchid occurs in a Natural Area adjacent to the western border of the site (Pounds et al. 1993). Pink lady's-slippers are expected to occur throughout the Pine Ridge area (MMES 1992a). Preferred habitat within the site indicates a greater potential for occurrence of the barn owl, black vulture, Cooper's hawk, red-shouldered hawk, and sharp-shinned hawk. Surveys of the proposed site will be required to verify the presence of these and other plant and animal species.

Table 4.9-1. Federally and state-listed threatened, endangered, and other special-status species that potentially occur on or in the vicinity of the Oak Ridge Reservation.[a]

Common name	Scientific name	Status[b]	
		Federal	State
Plants			
Appalachian bugbane[c]	*Cimicifuga rubifolia*	C2	T
Butternut	*Juglans cinerea*	C2	T
Canada (wild yellow) lily[c]	*Lilium canadense*	NL	T
Carey's saxifrage[c]	*Saxifraga careyana*	NL	S
Fen orchid[c]	*Liparis loeselii*	NL	E
Ginseng[c]	*Panax quinquefolius*	NL	T
Golden seal[c]	*Hydrastis canadensis*	NL	T
Gravid sedge[c]	*Carex gravida*	NL	S
Lesser lady's tresses[c]	*Spiranthes ovalis*	NL	S
Michigan lily	*Lilium michiganense*	NL	T
Mountain witch alder[c]	*Fothergilla major*	NL	T
Northern bush honeysuckle[c]	*Diervilla lonicera*	NL	T
Nuttall waterweed[c]	*Elodea nuttallii*	NL	S
Pink lady's-slipper[c]	*Cypripedium acaule*	NL	E
Purple fringeless orchid[c]	*Platanthera peramoena*	NL	T
Spreading false foxglove[c]	*Aureolaria patula*	C1	T
Tall larkspur[c]	*Delphinium exaltatum*	C2	E
Tubercled rein-orchid[c]	*Platanthera flava* var. *herbiola*	NL	T
Virginia spiraea	*Spiraea virginiana*	T	E
Fish			
Flame chub	*Hemitremia flammea*	NL	D
Tennessee dace[c]	*Phoxinus tennesseensis*	NL	D
Amphibians			
Green salamander	*Aneides aeneus*	NL	D
Hellbender[c]	*Cryptobranchus alleganiensis*	C2	D
Tennessee cave salamander[d]	*Gyrinophilus palleucus*	C2	T
Reptiles			
Cumberland turtle	*Chrysemys scripta troosti*	NL	D
Eastern slender glass lizard	*Ophisaurus attenuatus longicaudus*	NL	D
Northern pine snake	*Pituophis melanoleucus*	C2	T
Six-lined racerunner[d]	*Cnemidophorus sexlineatus*	NL	D
Birds			
Bachman's sparrow	*Aimophila aestivalis*	C2	E
Bald eagle[e]	*Haliaeetus leucocephalus*	E	E

Table 4.9-1. (continued).

Common name	Scientific name	Status[b] Federal	State
Birds (continued)			
Barn owl[c]	*Tyto alba*	NL	D
Bewick's wren	*Thyromanes bewickii altus*	C2	T
Black-crowned night heron[c]	*Nycticorax nycticorax*	NL	D
Black vulture[c]	*Coragyps atratus*	NL	D
Cooper's hawk[c]	*Accipiter cooperii*	NL	T
Grasshopper sparrow	*Ammodramus savannarum*	NL	T
Northern harrier	*Circus cyaneus*	NL	T
Osprey[c]	*Pandion haliaetus*	NL	E
Peregrine falcon	*Falco peregrinus*	E	E
Red-shouldered hawk[c]	*Buteo lineatus*	NL	D
Redheaded woodpecker	*Malanerpes erythrocephalus*	NL	D
Sharp-shinned hawk[c]	*Accipiter striatus*	NL	T
Mammals			
Eastern woodrat	*Neotoma floridana magister*	C2	D
Gray bat	*Myotis grisescens*	E	E
Indiana bat	*Myotis sodalis*	E	E
Smoky shrew	*Sorex fumeus*	NL	D
Southeastern shrew	*Sorex longirostris*	NL	D

a. Sources: Barclay (1990, 1992); Bay (1991); Cunningham et al. (1993); Hardy (1991), Hardy et al. (1992); Kitchings and Story (1984); Kroodsma (1987); ORNL (1981); ORNL (1988); TDEC (1992a, 1992b, 1992c, 1992d); TWRC (1991a, 1991b); U.S. DOI (1990, 1991, 1992).

b. Status codes:
C1 = Federal Candidate - Category 1 (probably appropriate to list)
C2 = Federal Candidate - Category 2 (possibly appropriate to list, more study required)
D = species deemed in need of management
E = endangered
NL = not listed
S = species of special concern
T = threatened, more study required

c. Recent record of species occurrence on the ORR.

d. Species collected on the ORR in 1964 (ORNL 1988).

e. Observed near ORR on Melton Hill and Watts Bar Lakes.

4.10 Noise

The major noise sources within the ORR occur primarily in developed operational areas and include various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). Major noise sources outside the operational areas consist primarily of vehicles and railroad operations. At the site boundary, away from most of these activities, noise from these sources would be barely distinguishable from background noise levels. Some disturbance of wildlife activities might occur on the ORR as a result of operational activities and construction activities.

Sound-level measurements have been made around the ORR in the process of testing sirens and preparing support documentation for the Atomic Vapor Laser Isotope Separation site (Cleaves 1991). The acoustic environment along the ORR site boundary in rural areas and at nearby residences away from traffic noise is typical of a rural location, with the average day-night sound level in the range of 35 to 50 decibels, A-weighted. Areas near the site within Oak Ridge are typical of a suburban area with the average day-night sound level in the range of 53 to 62 decibels, A-weighted (EPA 1974). The primary source of ORR noise at the site boundary and at residences near the site boundary is traffic, including trucks, private vehicles, and freight trains. During peak hours, plant vehicular traffic is a major contributor to traffic noise levels in the area. In addition, some noise due to air cargo and business travel via commercial air transport through the airport at Knoxville can be attributed to ORR operations. Section 4.11 (Traffic and Transportation) discusses vehicular, air, and rail transportation.

The State of Tennessee has not established specific numerical environmental noise standards applicable to the ORR. The City of Oak Ridge has specified allowable noise levels at property lines as shown in Table 4.10-1.

During a normal week, about 17,000 employees travel to the ORR each day in private vehicles from surrounding communities. In addition, both government-owned and private trucks pick up and deliver materials at the site. Based on the number of employees, it was estimated that about 33,000 vehicle trips are generated to and from the site each day; mostly on Tennessee

Table 4.10-1. City of Oak Ridge maximum allowable noise limits applicable to the ORR.[a]

Adjacent uses	Where measured	Maximum sound level (dBA)[b]
All residential districts	Common lot line	50
Neighborhood business district	Common lot line	55
General business district	Common lot line	60
Industrial district	Common lot line	65
Major streets	Street lot line	75
Secondary residential streets	Street lot line	60

a. Source: City of Oak Ridge (1984).

b. Decibels, A-weighted.

State Routes 58, 62, 95, and 162, which pass through the ORR and are open to the general public. Both government-owned and private trucks pick up and deliver materials at the site. The contribution of ORR operations to traffic volumes along these routes, especially during peak traffic periods, affects noise levels in the immediate vicinity of the ORR and through the City of Oak Ridge.

Use of the railroad branches from the CSX and the Norfolk Southern Corporation lines to deliver and pick up shipments at the ORR may cause some noise impacts along these routes. Twice a week service is scheduled to Y-12 from the CSX line. However, only 60 cars were delivered in 1993. Service to K-25 is provided as needed. Only three or four trains serviced K-25 in 1993. However, two or three trains per week may be required beginning in 1994 (Pearman 1994). Noise sources from rail transport include diesel engines, wheel-track contact, and whistle warnings at rail crossings.

4.11 Traffic and Transportation

Traffic congestion is measured by level of service. Level of service A represents free flow of traffic. Level of service B is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Level of service C is in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. Level of service D represents high-density, but stable, flow. Level of service E represents operating conditions at or near the capacity level. Level of service F is used to define forced or breakdown flow. The calculated level of service are for discrete locations along a segment. Level of service will most likely be worse in urban areas and better in rural areas along the segment.

The Region of Influence for the ORR includes site roads and regional roads in Anderson, Blount, Knox, Loudon, and Roane counties. Regional and local transportation routes are presented in Figure 4.11-1 and Figure 2.1-2.

Primary roads on the ORR include Tennessee State Routes 95, 62, 162, and 170 (Bethel Valley Road), and Bear Creek Road. Except for Bear Creek Road, all are public roads. The remaining roads on the ORR are private. Interstate 75 and Tennessee State Routes 162, 62, and 61 form a loop around ORR. Bear Creek Road, Bethel Valley Road, Tennessee State Routes 62

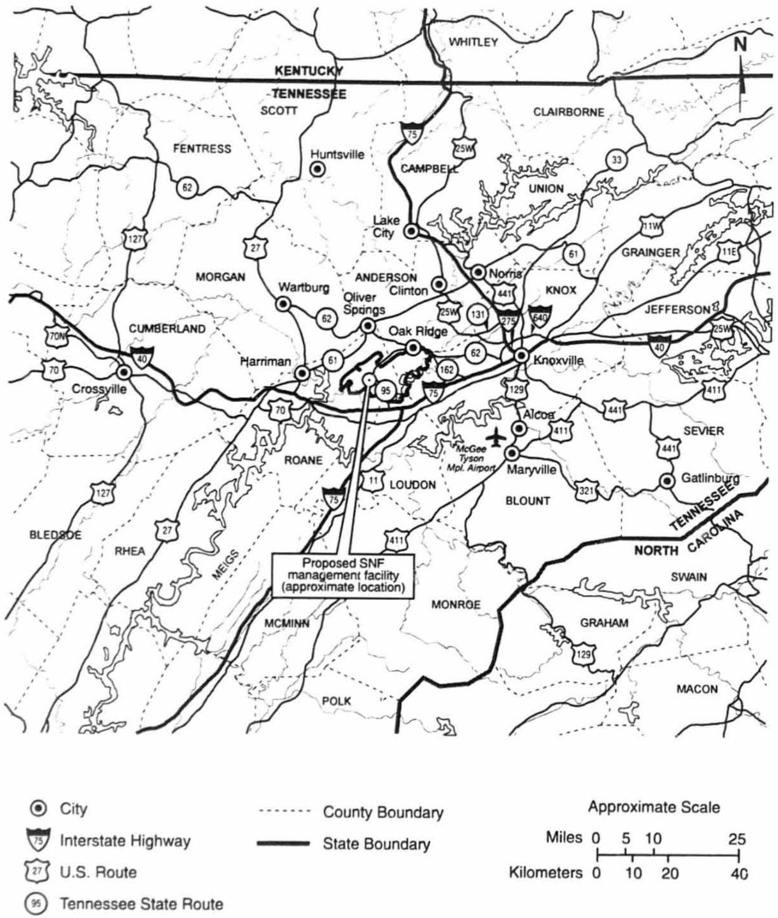


Figure 4.11-1. Oak Ridge Reservation regional transportation map.

and 95 experience high average traffic and peak hour volume. Other areas on the site that have traffic problems include Scarboro Road, security entrances, and intersections.

Current baseline traffic (i.e., 1995) along segments providing access to the ORR is projected to contribute to differing service level conditions (TDOT 1993). Tennessee State Route 61 would operate at level of service D between Interstate 75 at Norris and U.S. Route 25W at Clinton, and at level of service C between U.S. Route 25W at Clinton to Tennessee State Route 62 east of Oliver Springs. Tennessee State Routes 58 and 170 (providing access from the east), as well as Bear Creek Valley Road, would operate between level of service D and B. Tennessee State Routes 62 and 95 would operate at widely varying levels of service in the vicinity of ORR. Tennessee State Route 62 would operate at a level of service E between Tennessee State Route 95 at Oak Ridge and Tennessee State Route 170. Tennessee State Route 95 would operate at a level of service E between Tennessee State Route 61 and Tennessee State Route 62 at Oak Ridge.

Road reconstruction, widening, modification of interchanges, and new interchange construction projects are planned for segments of Bear Creek Valley Road, Scarboro Road, and Tennessee State Routes 58, 62, and 95 (Johnson, C. 1994; MMES 1991b).

Current baseline traffic along segments providing regional access to the ORR is projected to contribute to differing service level conditions. Interstate 40 passes within 5 miles (8 kilometers) to the south of the ORR. It has a level of service of A to B between U.S. Route 27 at Harriman to Interstate 75, which passes northeast about 11 miles (18 kilometers) and south about 3 miles (5 kilometers) of the ORR. U.S. Route 25W passes the ORR about 10 miles (16 kilometers) to the east and northeast. It has a level of service of D to E between Interstate 75 at Lake City to Tennessee State Route 131.

In 2001, when site-related impacts are at their highest along segments providing access to the ORR, background traffic is projected to contribute to differing service level conditions for local roads. Tennessee State Route 61 would operate at level of service D between Interstate 75 at Norris and U.S. Route 25W at Clinton and level of service C between U.S. Route 25W at Clinton to Tennessee State Route 62 east of Oliver Springs. Tennessee State Routes 58 and 170 as well as Bear Creek Valley Road would operate between level of service D and B. Tennessee State Routes 62 and 95 would operate at widely varying levels of service in the vicinity of the

ORR, with a level of service F between Tennessee State Route 95 at Oak Ridge and Tennessee State Route 162. U.S. Routes 11/70 would operate at level of service F between Tennessee State Route 131 and U.S. Routes 11E/11W Split. All other local roads operate at level of service E or better (University of Tennessee 1993). Interstate 40 has a level of service B to D between U.S. Route 27 at Harriman to Tennessee State Route 162.

The level of service was calculated using average daily traffic counts (TDOT 1990) and standard parameters (ITE 1991; TRB 1985; Rand McNally 1993).

No public transportation service exists in the City of Oak Ridge. Other modes of transportation within the Region of Influence include railways and waterways. Railroad service in the Region of Influence is provided by CSX Transportation and the Norfolk Southern Corporation. Two main lines serve the ORR. A CSX Transportation spur line serves the ORR site as well as the City of Oak Ridge. Waterborne transport in the Region of Influence is via the Clinch River, which provides an alternative mode of transportation to the Oak Ridge area. The Clinch River waterway has rarely been used for DOE business, and no designated port facilities exist for such purposes (Corps 1991).

McGhee Tyson Airport in Knoxville, 40 miles (64 kilometers) from the ORR, receives jet air passenger and cargo services from both national and international carriers. The closest air transportation facility to ORR is Atomic Airport in Oliver Springs. Numerous other private airports are located throughout the Region of Influence (DOT 1991).

4.12 Occupational and Public Health and Safety

The Department of Energy's Oak Ridge Reservation released chemicals and small quantities of radionuclides to the environment from operations at all facilities during 1992. These releases are quantified and characterized in detail in the Oak Ridge Environmental Report for 1992. This release information, along with estimates of the potential consequences resulting from these releases, is summarized in greater detail within sections 4.7, 5.7, 4.8, and 5.8 for the purpose of characterizing the existing radiation and chemical environment. The ORR baseline data presented within this section are expected to remain essentially constant between 1992 and 1995 (the year in which SNF operations are expected to commence).

Health effects from radiation are presented here as the risk of fatal cancer. This risk is in the ratio of the health risk estimator (risk of fatal cancer per rem of exposure). The value of this estimator for exposures to the public is 5×10^{-4} for fatal cancers. The corresponding estimator for exposures to workers is 4×10^{-4}.

4.12.1 Atmospheric Emissions and Doses

Table 4.7-1 in Section 4.7 illustrates the breakdown of radioactive emissions to the atmosphere from each of the three ORR operations areas (ORNL, K-25, and Y-12), during 1992. The calculated total dose of 3.3 millirem/year due to 1992 operations, to the maximally exposed individual at the site boundary, is well within the 10 millirem/year limit given in 40 CFR Part 61 (the U.S. Environmental Protection Agency's National Emission Standards for Hazardous Air Pollutants) (MMES 1993a).

The concentrations at the ORR boundary of all radionuclides released to the atmosphere from the three operations areas in 1992 were less than 1 percent of the DOE Derived Concentration Guide, which is based upon an exposure of 100 millirem; this equates to a dose of less than 1 millirem (MMES 1993a).

The associated isotopic gaseous release cancer risks are presented within Section 4.12.4.

Table 4.7-2 in Section 4.7 presents the chemical releases for 1992 in a fashion analogous to Table 4.7-1. All of these releases are within permitted levels. The associated chemical release cancer risks are presented within Section 4.12.6.

4.12.2 Groundwater/Surface Water Contamination and Doses

Referring to the various water contamination data presented in Section 4.8, it was found that a plausible 0.62 mrem/year of site operation could be incurred by a potential maximally exposed individual at the site boundary due to water ingestion, fish ingestion, and other associated factors (see Table 4.12-1) (MMES 1993a).

Additionally, a dose of 17 mrem/year of site operation could be incurred by this potential maximally exposed individual, due to external exposure from contaminated liquid effluents (see

Table 4.12-1. Summary of estimated radiation dose to public from 1992 operations at ORR.

Pathway	Location of maximally exposed individual	Committed effective dose equivalent to maximally exposed individual (mrem)	Collective committed effective dose equivalent (person-rem)[a]
Gaseous effluents	Nearest resident to		
Inhalation plus direct radiation from air, ground, and food chains	Y-12 Plant	2.7	29
	ORNL	0.06	2
	K-25 Site	0.53	21
	ORR	3.3	52
Liquid effluents			
Drinking water	Gallaher	0.2	0.85
Eating fish	Poplar Creek	0.4	1.0[b]
Other activities	Poplar Creek	0.02	
Direct radiation[b]	Clinch River shoreline	2	
	Poplar Creek (K-25 Site)	15	

a. Within 80 kilometers (50 miles) of the ORR.

b. Includes doses from all liquid pathways (MMES 1993a).

Table 4.12-1). Fifteen mrem/year of this dose would result from a hypothetical individual fishing for 250 hours/year along Poplar Creek near the K-25 storage areas (MMES 1993a).

The associated cancer risks related to these doses are presented in Section 4.12.4.

4.12.3 External Gamma Radiation

External gamma radiation measurements were made with thermoluminescent dosimeters at locations coinciding with the ambient air locations. The average external gamma radiation level at the ORR perimeter for 1992 was 7.6 microroentgens per hour. All of the measurements were well within the range of typical values for cities in the United States (MMES 1993a).

4.12.4 Radiation Dose and Health Effects Summary (Public and ORR Workers)

A summary of the effective dose equivalents to the hypothetical maximally exposed individual from the important pathways of exposure during 1992 is presented in Table 4.12-1. If the resident who receives the highest effective dose equivalent (3.3 millirem) from gaseous effluents also drank water from the Gallaher area (0.2 millirem), and went fishing at Poplar Creek (for 250 hours/year) near the K-25 site (15 millirem), that individual would receive a total effective dose equivalent of approximately 18.5 millirem, which is roughly 6.3 percent of the annual dose (295 millirem) from natural background radiation (see Figure 4.7-2). All of these doses are within the applicable regulatory requirements, (i.e., 4 millirem/year from the drinking water pathway, 10 millirem/year from the airborne release pathways, and 100 millirem/year total for all pathways) (MMES 1993a).

The risk of fatal cancer to the maximally exposed individual at the site boundary (due to atmospheric emissions only) is 1.7×10^{-6} per year of operation, and the corresponding (ingestion) risk to this maximally exposed individual from drinking water is 1.0×10^{-7} per year of operation. The risk of fatal cancer from direct radiation due to an individual's spending 250 hours/year fishing at Poplar Creek (K-25 Site) is 7.5×10^{-6} per year of exposure. A more realistic maximally exposed individual scenario from direct radiation, an individual spending 250 hours/year along the Clinch River shoreline near a field on which cesium-137 experiments were performed, yields an associated risk of 1×10^{-6}. The resulting risk to the maximally exposed individual is 9.2×10^{-6} per year of operation; over the 40-year SNF management facility lifetime this risk would be 3.7×10^{-4}.

Table 4.12-1 also includes the collective doses to the general population within 50 miles (80 kilometers) of the ORR. It was found that approximately 54 person-rem (which translates to an expected 0.027 fatal cancer) were received (from liquid and gaseous effluents) by this population from 1992 ORR operations. Thus, over a 40-year period, there would be approximately 1.1 fatal cancers expected.

Doses to onsite workers at the ORR have been reported by DOE for 1991 operations. Of the approximately 17,000 workers monitored, the maximally exposed individual was reported to receive 1 to 2 rem (assumed as 2 rem), which is well below the DOE guidelines of 5 rem (DOE 1992a). The average dose to workers at the site was 2.8 mrem/yr. The risk of fatal cancer to the average worker is 1.1 x 10^{-6} per year of operation; the risk to a worker who spent 40 years at ORR is approximately 4.5 x 10^{-5}. Additionally, the total collective (population) dose received by these workers was 48 person-rem, which corresponds to 0.019 fatal cancers per year of exposure. Over a 40-year period, there would be an expected 0.76 fatal cancer to this worker population.

4.12.5 Health Effects Studies

Two epidemiologic studies were conducted to determine whether the ORNL facility contributed to any excess cancers in the communities surrounding the facility. One study found no excess cancer mortality in the population living in counties surrounding ORNL when compared to the control populations located in other nearby counties and elsewhere in the United States (Jablon et al. 1991). The other found slight excess cancer incidences of several types in the counties near ORNL, but none of the excess risks were statistically significant (Sharpe 1992).

An Oak Ridge health assessment study is ongoing. This study will include a reconstruction of doses received by the public from historical releases of radioactivity from the reservation. To date, a Phase I report has been issued (Tennessee Department of Health and the Oak Ridge Health Agreement Steering Panel 1993).

Studies of workers at Oak Ridge National Laboratory (Jablon et al 1991; Wing et al. 1993) showed an excess of leukemia deaths among maintenance workers and engineers who had worked for more than 10 years, suggesting a possible excess attributed to exposures other than

radiation. An increase of 2.68 percent in deaths from all causes and 4.94 percent for all cancers with every rem of cumulative dose exposure with a 20-year exposure lag was also reported. Excess cancer deaths were associated with working in radioisotope production and chemical operations but not with work in physics, engineering, or unknown job categories. Cancer mortality was also associated with exposure to beryllium, lead, and mercury.

In March 1990, the Secretary of Energy announced that DOE would turn over responsibility for analytical epidemiologic research on long-term health effects on workers at DOE facilities and surrounding communities to the Department of Health and Human Services, and directed that worker health and exposure data be released. A Memorandum of Agreement with the Department of Health and Human Services was signed in January 1991. The Department of Health and Human Services is now conducting the ongoing health effects research program. To develop a database on workers, DOE has initiated an Epidemiologic Surveillance Program and Health-Related Records Inventory.

4.12.6 Chemical Dose and Health Effects Summary

Table 4.7-2 in Section 4.7 presents the ORR chemical releases for 1992. Exposure to chemicals released from the ORR was compared with acceptable levels of exposure (no adverse effect from noncarcinogens) for the ingestion exposure pathway via drinking water and consumption of fish. Aluminum, nitrate, and polychlorinated biphenyls were measured above acceptable levels in upper Bear Creek; the ratios of their doses to acceptable doses were 3.4, 2.2, and 11.1, respectively. The only other chemical exposure attributable to ORR operations that was found to exceed acceptable levels was mercury. This noncarcinogen was found in fish caught from the Clinch River. The ratio of the mercury dose to acceptable dose levels was found to be 1.1 (MMES 1993a).

Because of concerns for possible contamination of the population by mercury, the Tennessee Department of Health and Environment conducted a pilot study in 1984. The study showed no difference in urine or hair mercury levels between individuals with potentially high mercury exposures (residence or activity in contaminated areas based on soil measurements or consumption of fish caught in the contaminated areas) and those with little potential exposure. Mercury levels in some soils measured as high as 2,000 parts per million. Analysis of a few soil samples showed that most of the mercury in the soil was inorganic, however, thereby lowering the probability of bioaccumulation and health effects. Planned occupational studies at the ORR include a 24-month clinical follow-up of 111 heavily exposed mercury workers (Wing et al. 1991).

4.13 Utilities and Energy

4.13.1 Water Consumption

Both the Clinch River and the Melton Hill Reservoir supply water to the ORR. Because they are a part of the TVA flood control system, they are capable of maintaining a constant volume of water well in excess of the demands of the ORR (MMES 1993a).

In 1995, water supply facilities at the ORR will have a capacity of approximately 1,761 liters per second (27,916 gallons per minute). In 1993, the average demand for water on the ORR water supply facilities was approximately 801 liters per second (12,708 gallons per minute) (Fritts 1994).

A pumping station near Y-12 on the Melton Hill Reservoir supplies untreated water to the DOE water treatment plant. After treatment, the water is stored in two reservoirs with a combined capacity of 26 million liters (7 million gallons). From the reservoirs, water is supplied by gravity flow to the Y-12 operations site, ORNL, the Scarboro Facility (which houses the Oak Ridge Institute of Science and Education's Energy/Environmental Systems Division), and the City of Oak Ridge (MMES 1994a).

A pumping station on the Clinch River provides water to the K-25 water system. After treatment, the water is stored in two water storage tanks on Pine Ridge. This system provides water to the K-25 Site, the Transportation Safeguards Facility, and the city's Clinch River Industrial Park (MMES 1994a).

The SNF facilities will be supplied with water from the K-25 water system. In 1995, the K-25 water system will have a capacity of approximately 184 liters per second (2,917 gallons per minute). In the years 1988 to 1994, K-25 water usage varied from a high of 97 liters per second (1,533 gallons per minute) in 1990 to a low of 78 liters per second (1,235 gallons per minute) in 1988. In 1994, the average demand was 84 liters per second (1,324 gallons per minute). Significant growth in water capacity or demand is not expected (Fritts 1994).

4.13.2 Electrical Consumption

The ORR electrical system is supplied power from four major power sources in the TVA system: Kingston Steam Plant, Bull Run Steam Plant, Wolf Creek Hydroelectric Plant, and Fort Loudon Hydroelectric Plant. The K-25 Power Operations Department manages and operates the electrical transmission and substation system of the ORR (MMES 1994a).

Three substations located at the K-25, Y-12, and ORNL sites comprise the ORR power system. The substations are tied together onsite by five DOE 161-kilovolt transmission lines. Power is supplied to ORR substations by six TVA electrical lines at 161 kilovolts, which is reduced to 13.8 kilovolts for distribution (MMES 1994a).

In 1995, the connected capacity of ORR facilities would be approximately 920 megavolt-amperes. From 1989 through 1993, the peak demand of electricity varied from a high of 116 megavolt-amperes in 1989 to a low of 98 megavolt-amperes in 1993 (Fritts 1994).

4.13.3 Fuel Consumption

The East Tennessee Natural Gas Company supplies natural gas to the ORR, transporting the gas from the supply areas through upstream pipelines and then through its own pipeline system for ultimate delivery to the ORR (MMES 1994a). By contract, ORR natural gas capacity is 7,600 decatherms. This amount can be increased if necessary. In 1994, the average daily usage of natural gas was 3,600 decatherms (Fritts 1994).

Coal is used to produce steam at ORNL and as a backup fuel at the Y-12 steam plant. Y-12 plans to use more coal in the future as a replacement for natural gas (Fritts 1994).

4.13.4 Wastewater Disposal

The ORR does not have a centralized sewage system for all facilities. The K-25 Site and ORNL have their own sewage systems, while Y-12 shares sewage lines with the City of Oak Ridge (MMES 1994a).

The sanitary sewage effluent from the Y-12 operations area flows to the Oak Ridge West End Treatment Plant. DOE maintains the sewage lines extending from Y-12 to the east end of the security road (Bear Creek Road). The City of Oak Ridge maintains the sewage lines from the end of the security road to the treatment plant on West Oak Ridge Turnpike (MMES 1994a).

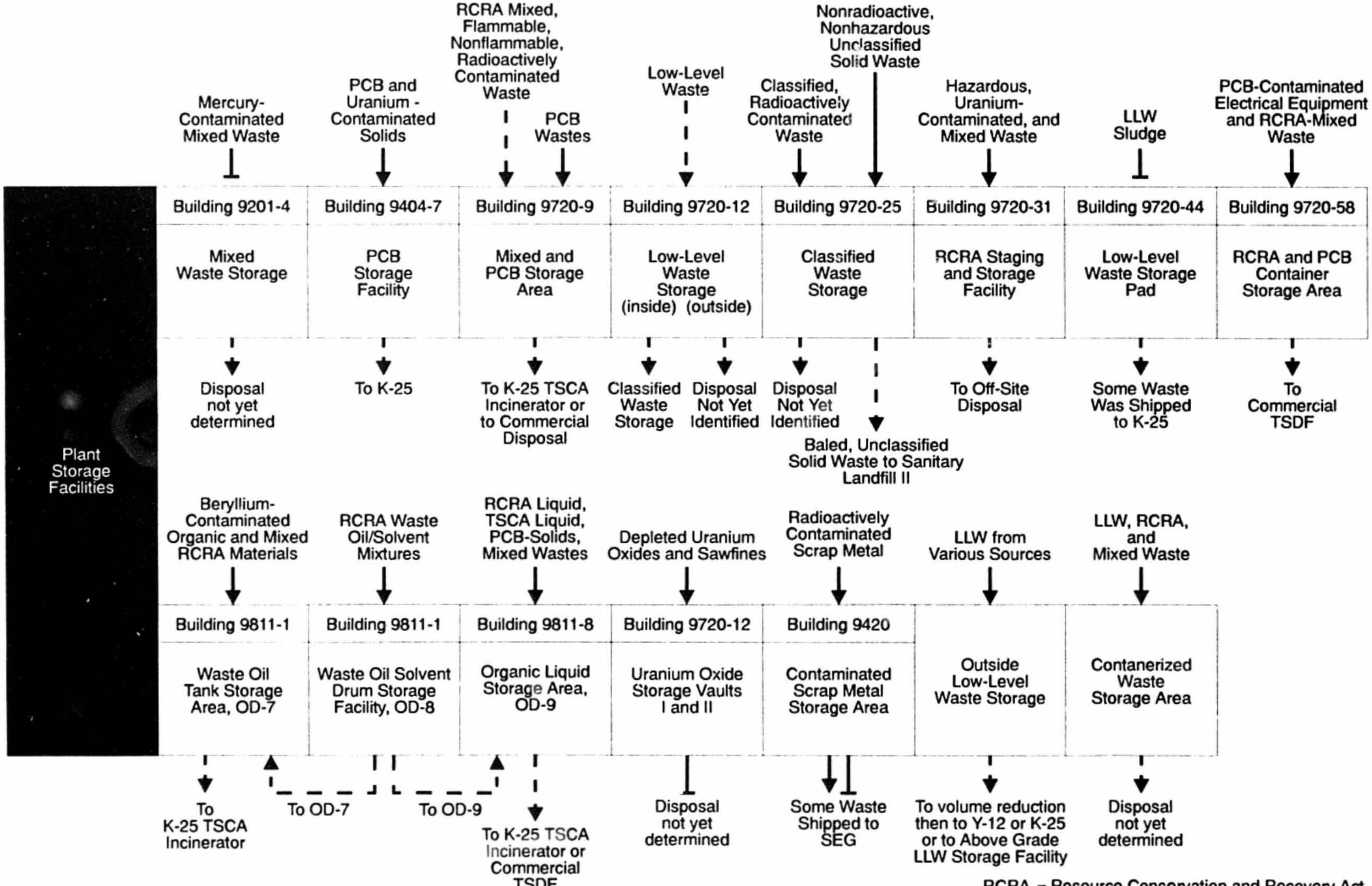
The sewage treatment plant for ORNL discharges treated effluent into White Oak Creek in full compliance with all permit requirements (MMES 1994a). There are no anticipated capacity problems with the K-25 sanitary sewage system, which is permitted by the National Pollution Discharge Elimination system (MMES 1994a).

The SNF management facility could use the K-25 sanitary sewer treatment system, located directly north of the proposed SNF site. The K-25 system has a capacity of 26 liters per second (417 gallons per minute). From 1988 to 1994, wastewater production peaked at 24 liters per second (378 gallons per minute) during wet conditions in 1994 (Fritts 1994). As an alternative, a new onsite sanitary sewage system and wastewater treatment plant might be required for the proposed SNF management facility.

4.14 Materials and Waste Management

This section describes the hazardous materials management (chemical raw materials), the waste categories, and the ongoing waste management activities, including onsite treatment, onsite storage, onsite waste disposal, and preparation for appropriate offsite disposal, for the three primary complexes within the ORR: the Y-12 Plant, the K-25 Site, and the ORNL (see Figure 2.1-2). Ongoing nuclear-related activities at the ORR have resulted in the generation of low-level, mixed low-level, hazardous, transuranic, spent nuclear fuel (see Chapter 2 for discussion), and industrial solid waste categories, which are discussed in this section. Section 4.8 discusses nonhazardous liquid waste treatment. A description of the Y-12 Plant, the K-25 Site, and ORNL waste categories and the waste management process unique to each of these complexes follows.

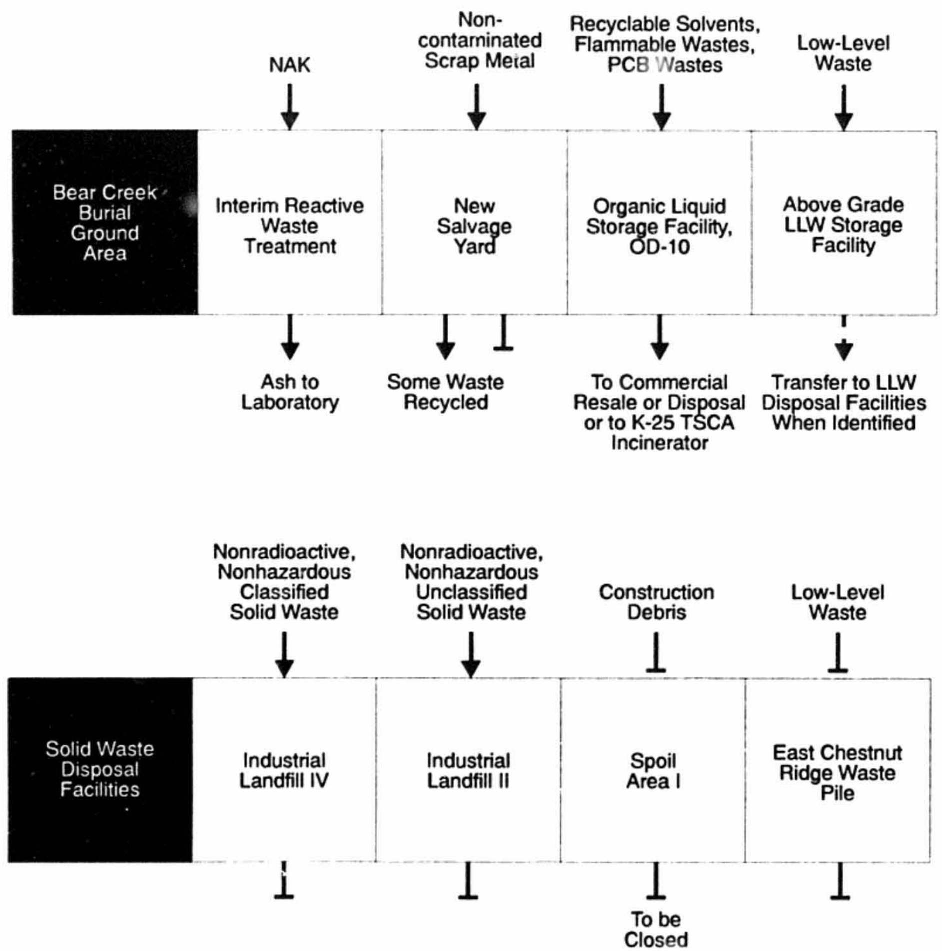
Facilities at the Y-12 Plant are being used to manage low-level radioactive, hazardous (Resource Conservation and Recovery Act hazardous/mixed polychlorinated biphenyl and polychlorinated biphenyl/uranium), and nonhazardous solid wastes. Figure 4.14-1 shows the waste management process at the Y-12 Plant.



Source: Modified from PAI Corporation 1993a

RCRA = Resource Conservation and Recovery Act
PCB = Polychrorinated Biphenyl
LLW = Low-level (radioactive) waste
TSDF = Treatment, Storage and Disposal Facility
TSCA = Toxic Substances Control Act
SEG = Scientific Ecology Group (contractor)
NAK = Sodium-Potassium

Figure 4.14-1. Flow diagram of Y-12 Plant storage and disposal units at ORR (Page 1 of 2).



Source: Modified from PAI Corporation 1993a

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LLW = Low-level (radioactive) waste
TSDF = Treatment, Storage and Disposal Facility
TSCA = Toxic Substances Control Act
SEG = Scientific Ecology Group (contractor)
NAK = Sodium-Potassium

Figure 4.14-1. Flow diagram of Y-12 Plant storage and disposal units at ORR (page 2 of 2).

Facilities at the K-25 Site are being used to manage low-level radioactive, hazardous, and mixed wastes. Nonhazardous solid wastes are disposed at the Y-12 Plant Sanitary Landfill. Figure 4.14-2 shows the waste management process at the K-25 Site.

Facilities at the ORNL are being used to manage transuranic, low-level radioactive, hazardous, and mixed waste. Nonhazardous solid wastes are disposed at the Y-12 Plant Sanitary Landfill. Figure 4.14-3 shows the waste management process at the ORNL.

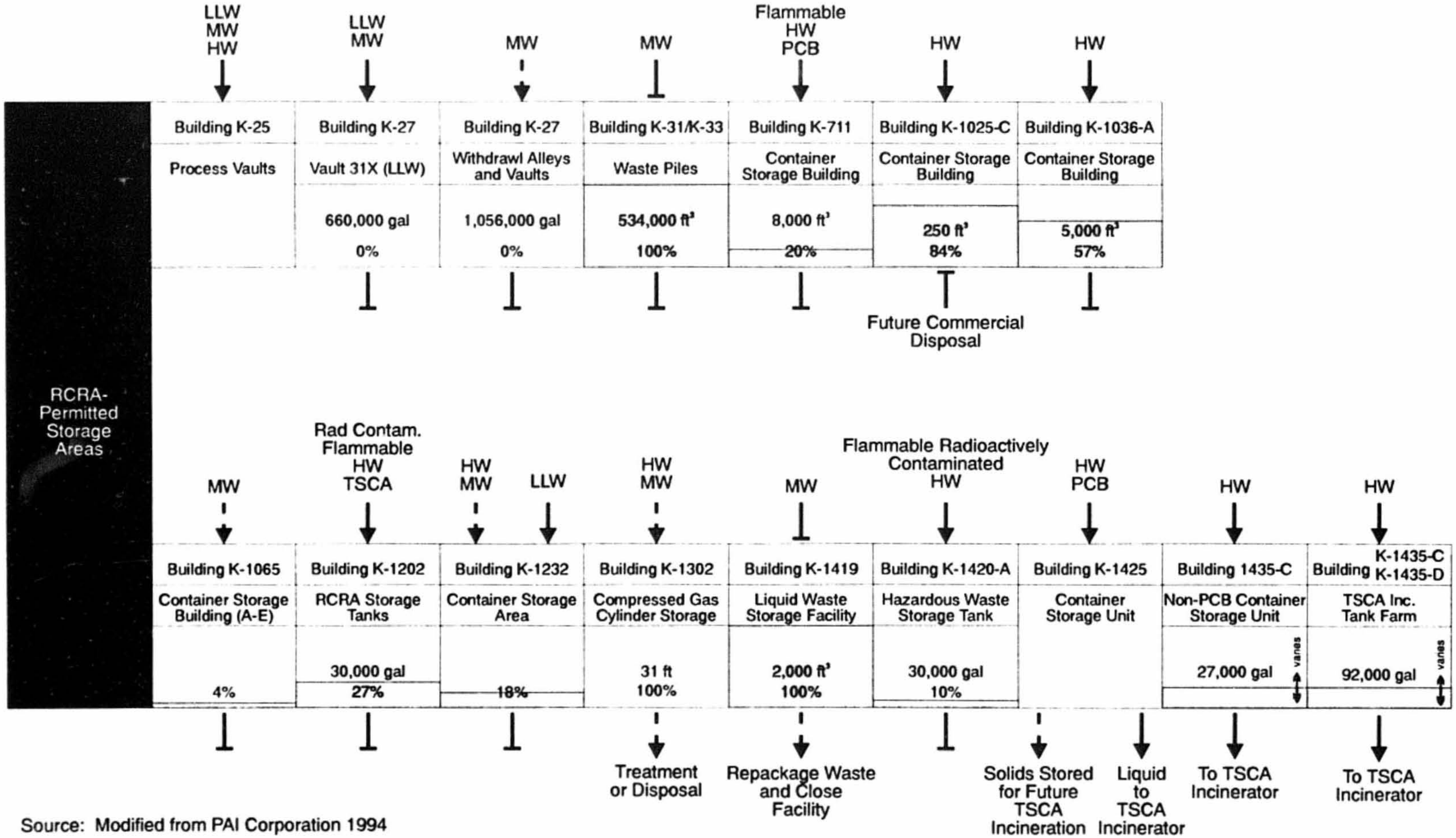
The overall ORR waste management activities, as well as details on the facilities used to manage wastes, are presented by waste category (transuranic, mixed low-level, low-level, hazardous, and industrial solid) in Sections 4.14.1 through 4.14.5 respectively. Note that the 1995 waste generation rates presented in tables associated with these sections are a representation of the annual generation rates for operations until the year 2035. Section 4.14.6 describes the management of the chemical raw materials used for ORR activities.

4.14.1 Transuranic Waste

The ORNL is the only complex at the ORR that generates and manages transuranic waste. Table 4.14-1 presents a summary of transuranic waste management activities projected for 1995, and details on the facilities used to manage transuranic wastes are presented in Table 4.14-2.

4.14.2 Mixed Low-Level Waste

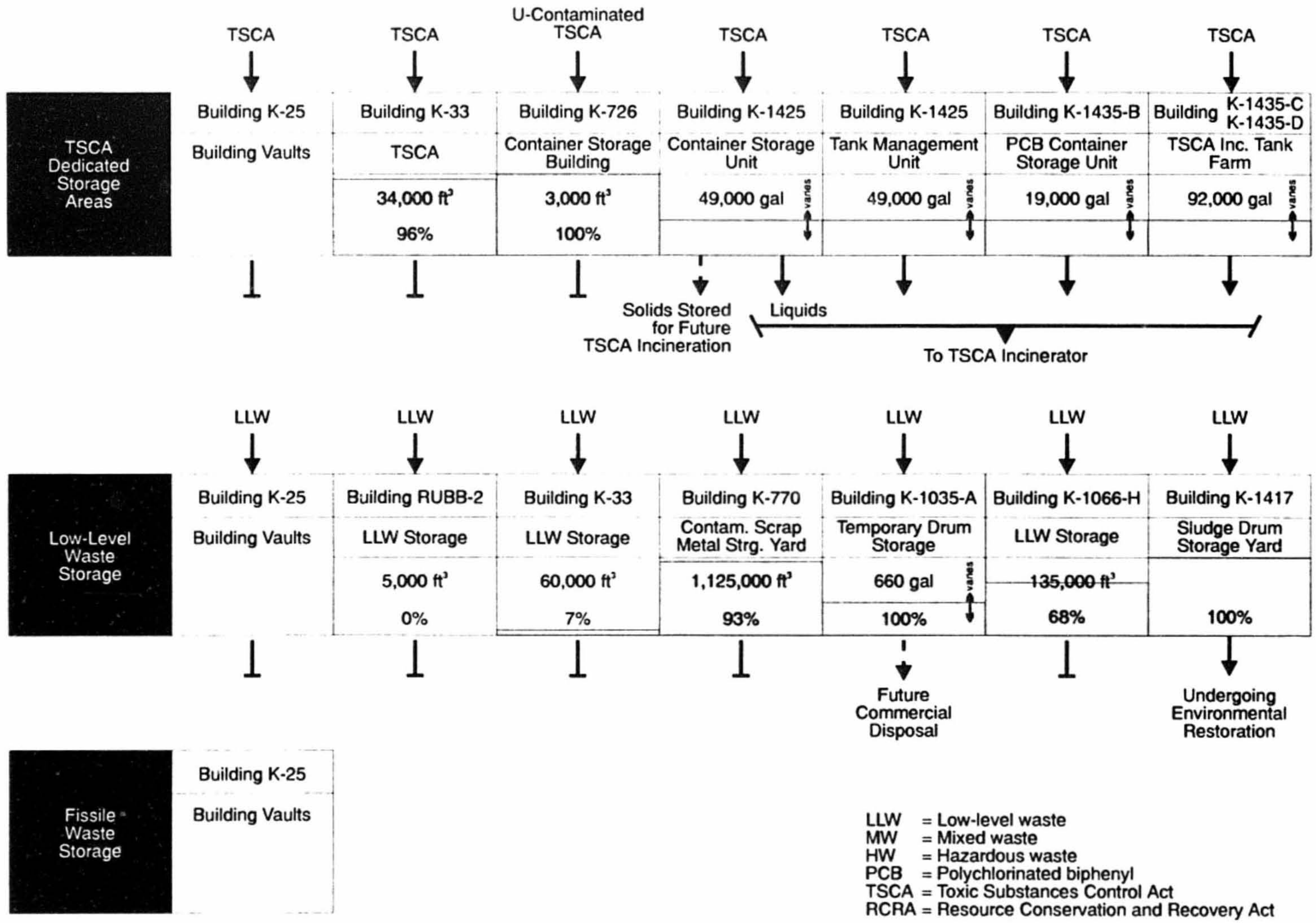
All three complexes at the ORR generate and manage mixed low-level wastes. The Y-12 Plant, K-25 Site, and the ORNL manage non-Resource Conservation and Recovery Act wastes (polychlorinated biphenyls, beryllium, and asbestos) contaminated by low-level radioactive materials as dangerous substances and include them with the Resource Conservation and Recovery Act-regulated radionuclide-contaminated materials as mixed wastes. Table 4.14-3 presents a summary of mixed low-level waste management activities projected for 1995, and details on the facilities used to manage mixed low-level waste are presented in Table 4.14-4.



Source: Modified from PAI Corporation 1994

LLW = Low-level waste
MW = Mixed waste
HW = Hazardous waste
PCB = Polychlorinated biphenyl
TSCA = Toxic Substances Control Act
RCRA = Resource Conservation and Recovery Act

Figure 4.14-2. Flow diagram of K-25 waste storage units at ORR (Page 1 of 2).



Source: Modified from PAI Corporation 1994

Figure 4.14-2. Flow diagram of K-25 waste storage units at ORR (Page 2 of 2).

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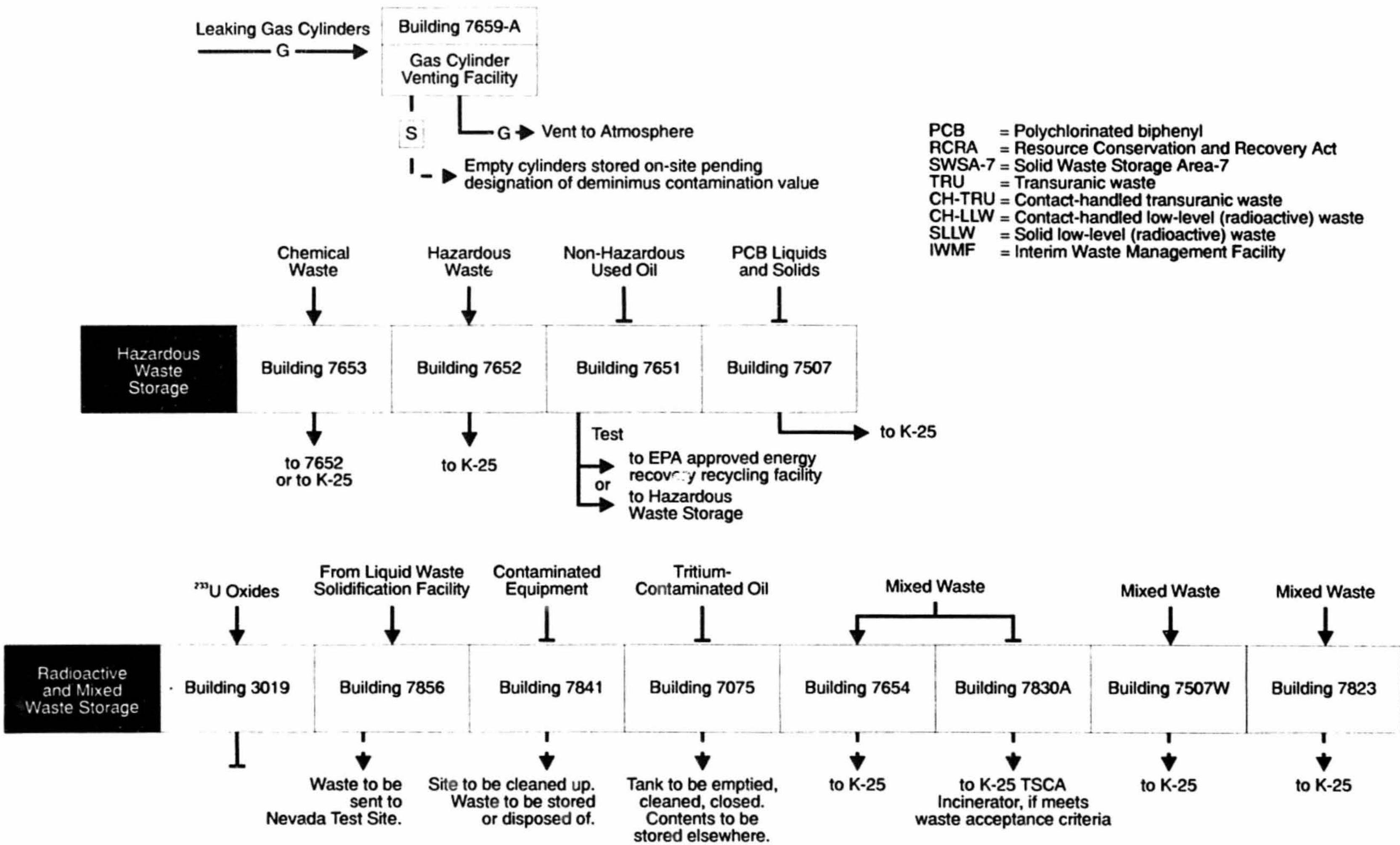

Source: Modified from PAI Corporation 1993b

Figure 4.14-3. Flow diagrams of ORNL waste treatment units and storage and disposal units at ORR (Page 1 of 2).

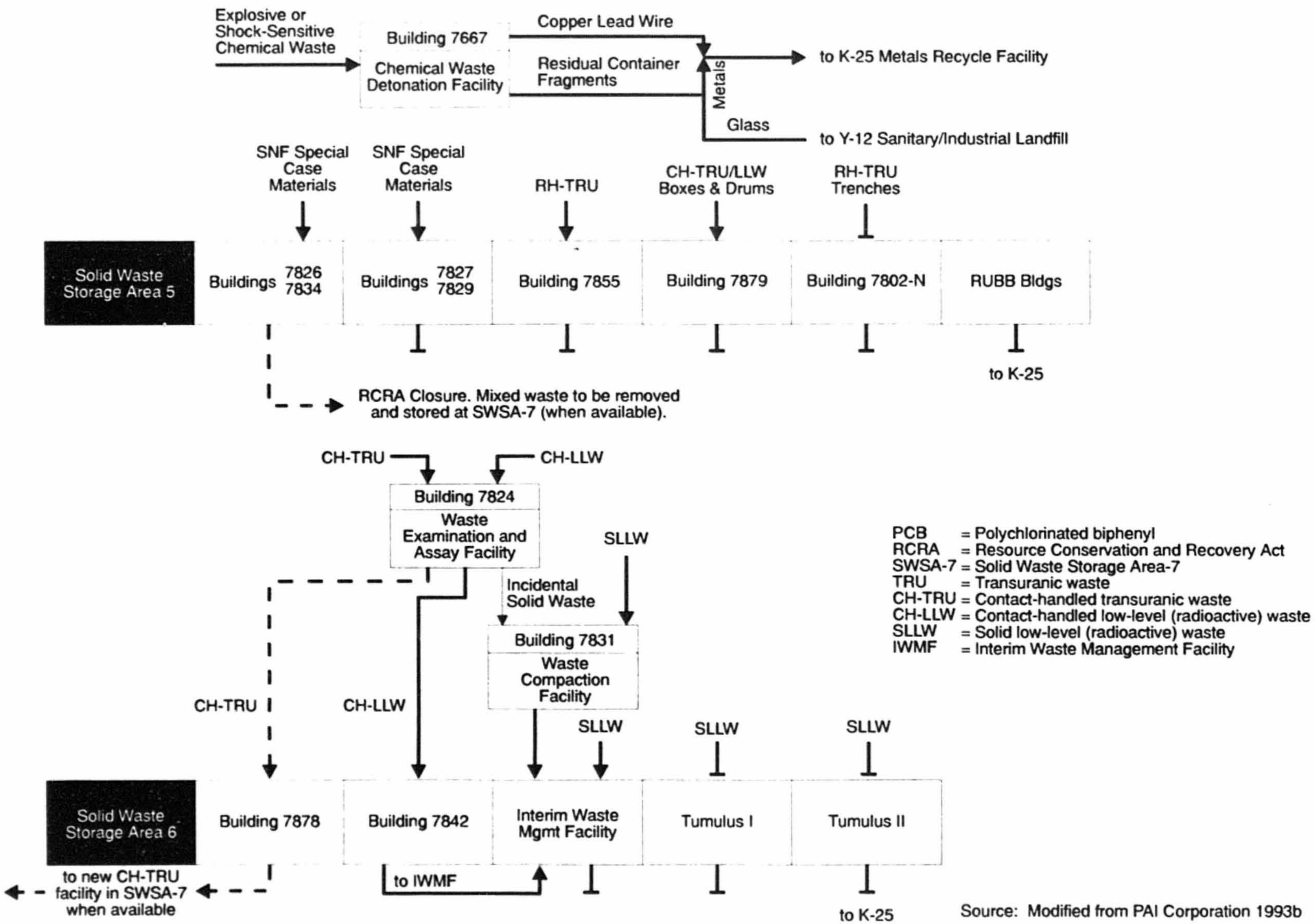

Figure 4.14-3. Flow diagrams of ORNL waste treatment units and storage and disposal units at ORR (Page 2 of 2).

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Table 4.14-1. Projected 1995 transuranic waste management activities at the ORR (ORNL complex).[a]

Waste category	Generation rate[b]	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Transuranic (Solid)							
Contact handled	10.7 m^3	None	Not available	Staged	611.7 m^3	WIPP[c], in future	To be determined
Remote handled	5.4 m^3	None	Not available	Shielded storage	221.7 m^3	WIPP[c], in future	To be determined

a. Sources: Snider (1993); Turner (1994).
b. 1991 data.
c. WIPP = Waste Isolation Pilot Plant

Table 4.14-2. Baseline transuranic waste management activities as of 1995 at the ORR (ORNL complex).[a,b]

Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Transuranic	7802N	TRU[c] trenches	199 concrete casks	None
	7855	RH-TRU[d] waste storage facility	108 concrete casks	6 concrete casks
	7878	Interim storage facility	Not applicable (inspection facility)	Not applicable (inspection facility)
	7824	Waste examination and assay facility (dual use facility)	Not available	Not available
	7879	CH-TRU[e]/LLW[f] solids storage (dual storage facility)	372 m^2	Facility full

a. Sources: PAI Corporation (1993a); Turner (1994).
b. 1993 data.
c. TRU = Transuranic waste.
d. RH-TRU = Remote-handled transuranic waste.
e. CH-TRU = Contact-handled transuranic waste.
f. LLW = Low-level (radioactive) waste.

Table 4.14-3. Projected 1995 mixed low-level waste management activities at the ORR.[a]

Complex	Waste category	Generation rate	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Mixed solid[b]	242,869 kg[c] (573 m^3/yr)	None	N/A	Staged for shipment	1,730 yd^3 [d]	None, offsite to NTS pending	N/A
	Mixed liquid[b]	1,537,234 kg[e] (426,120 gal/yr)	Settlement and filtration	8,716 m^3 yr (2.3 million gal/yr)	Tanks	573 m^3 [f] (152,000 gal)	None, offsite to NTS pending	N/A
K-25 Site	Mixed liquid[g]	47,022.9 m^3 [h]	Settlement and filtration/ incineration	58,400,000 gal	Onsite	97,167 m^3 [i]	Not applicable	Not applicable
	Mixed solid[g]	535.2 m^3 [j]	Planned	Planned	Onsite	120,206 m^3	None	Not applicable
ORNL	Mixed liquid[g]	Not reported	Ion exchange	259,199.4 m^3	None	Not applicable	Not applicable	Not applicable
	Mixed solid[g]	48.9 m^3 [k]	Planned	Planned	Staged for shipment	22,000 gal [l]	None, offsite to NTS pending	Not applicable

a. Sources: Snider (1993); Brown (1994c).

b. 1992 data.

c. Includes 37,434 kg of contaminated (radionuclides) asbestos beryllium oxide waste and 28,948 kg of polychlorinated biphenyl/uranium waste.

d. RCRA/PCB Warehouse (Building 9720-9), RCRA and PCB Container Storage Area (Building 9720-58), Container Storage Facility (Building 9720-12) and PCB Drum Storage Facility (Building 9407-7).

e. Includes 13,152 kg of polychorinated biphenyl/uranium waste.

f. OD-9 and OD-10.

g. 1991 data.

h. TSCA (Toxic Substances Control Act) incinerator waste water.

i. Includes permitted container (solid/sludges/liquid wastes) and tank (liquids) storage capacity.

Table 4.14-3. (continued)

j. May include some polychlorinated biphenyl-tainted waste.

k. Includes polychlorinated biphenyl and asbestos waste.

l. Mixed Waste Drum Storage Pads - Bldg 7507 W, Part A permit, 22,000 gal.

Table 4.14-4. Baseline mixed low-level waste management activities as of 1995 at the ORR.[a]

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Mixed[b]	9201-4	Mixed waste storage area	350 55-gal drums	17 55-gal drums
		9404-7	PCB storage facility (dual storage/use)	See hazardous wastes	See hazardous waste
		9720-9	Mixed and PCB[c] storage area (dual storage/use)	See hazardous wastes	See hazardous waste
		9720-31	RCRA[d] staging and storage facility (dual storage/use)	See hazardous wastes	See hazardous waste
		9720-58	RCRA[d] and PCB[c] container storage area (dual storage/use)	See hazardous waste	See hazardous waste
		9811-1	Waste oil tank storage area, OD-7 (dual storage/use)	See hazardous waste	See hazardous waste
		9811-8	Waste oil solvent drum storage facility OD-8 (dual storage/use)	See hazardous waste	See hazardous waste
		9811-8	Organic liquid storage area, OD-9 (dual storage/use)	See hazardous waste	See hazardous waste
		None	Containerized waste storage area (dual storage/use)	See low-level waste	See low-level waste
K-25 Site[f]	Mixed[e]	K-1065A, B, C, D, E	Container storage	5097 m^3	970 m^3
		K-1419	Liquid waste storage facility	61 m^3	Facility full
		K-31	Waste piles (dual storage/use facility)	6623 m^3	Facility full
		K-33	Waste piles (dual storage/use facility)	8,506 m^3	Facility full
		K-27	Withdrawal alleys and vaults	2,640,000 gal	Future facility
		K-27	Vault 31X	660,000 gal	Future facility
ORNL	Mixed	7075	Used oil storage tank	4,200 gal	Tank full (undergoing RCRA[d] closure)
		7507W	Mixed waste storage facility	82 m^3	Facility full

Table 4.14-4. (continued)

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
		7654	Long term hazardous waste storage facility	62 m^3	Facility full
		7823	Mixed waste storage facility	390 m^3	117 m^2
		7830A	Waste storage tank	5,000 gal	Tank full

a. Sources: PAI Corporation (1993b); PAI Corporation (1994); Turner (1994).

b. 1993 data.

c. PCB = Polychlorinated biphenyl.

d. RCRA = Resource Conservation and Recovery Act.

e. 1994 data.

f. For additional mixed waste facilities see hazardous waste facilities at the K-25 Site (Table 4.14-8).

4.14.3 Low-Level Waste

The Y-12 Plant, K-25 Site, and the ORNL generate and manage low-level wastes. Table 4.14-5 presents a summary of low-level waste management activities projected for 1995, and details on the facilities used to manage low-level waste are presented in Table 4.14-6.

4.14.4 Hazardous Waste

All three complexes at the ORR generate and manage hazardous wastes. The Y-12 Plant, K-25 Site, and the ORNL manage non-Resource Conservation and Recovery Act wastes (asbestos, oils, and polychlorinated biphenyls) as dangerous substances and include them with the Resource Conservation and Recovery Act-regulated wastes as hazardous wastes. Table 4.14-7 presents a summary of mixed hazardous waste management activities projected for 1995, and details on the facilities used to manage hazardous waste are presented in Table 4.14-8.

4.14.5 Industrial Solid Waste

The K-25 Site and the ORNL industrial solid wastes are disposed of at the Y-12 Plant Sanitary Landfill (PAI Corporation 1994; PAI Corporation 1993a). Table 4.14-9 presents a summary of industrial solid waste management activities projected for 1995 at the Y-12 Plant, and details on the facilities used to manage industrial solid waste are presented in Table 4.14-10.

4.14.6 Hazardous Materials

The ORR uses a variety of chemical raw materials for activities associated with metal finishing/plating, uranium recovery, laboratory services, cooling tower operation, and facility cleaning/maintenance operations. Examples of chemicals used at the ORR include acids (hydrochloric, nitric), organics (methanol, perchloroethylene), and inorganics (hydrogen fluoride, chlorine). Currently, 309 specific chemicals and 20 chemical categories are being reviewed for possible reporting under the Superfund Amendments and Reauthorization Act Section 313 requirements. For 1992, the ORR reported 7 extremely hazardous substances and 39 hazardous chemicals for the Y-12 Plant; 5 extremely hazardous substances and 16 hazardous chemicals for the K-25 Site; and 20 extremely hazardous substances and hazardous chemicals for ORNL (MMES 1993a).

Table 4.14-5. Projected 1995 low-level waste management activities at the ORR.[a]

Complex	Waste category	Generation rate[b]	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Low-level solid[b]	1,438,680 kg[c] (5,793 m^3/yr)	Compaction/ incineration	Offsite	Stored onsite at Y-12 or K-25	See mixed solids	N/A[d]	N/A
	Low-level liquid[b]	565,929 kg (148,186 gal/yr)	Settlement and filtration	20,644m^3/yr[e] (5,400,000 gal/yr)	Stored onsite	See mixed liquids	N/A	N/A
K-25 Site	Low-level liquid[f]	Included in mixed	Settlement and filtration	See mixed liquid	None	Not applicable	Not applicable	Not applicable
	Low-level solid[f]	978.7 m^3 [g]	Compaction/ smelting	Offsite	Onsite	See mixed[h]	Planned onsite non-metallic Planned offsite metallic	Planned
ORNL	Low-level liquid[f]	2,064.4 m^3	Neutralization & precipitation	1.5292M m^3 [i]	Stored onsite in underground tanks	573.5 m^3	None	Not applicable
	Low-level solid[f]	130 m^3 [j]	Compaction	Offsite	Onsite	32,770.8 m^3 [k]	Onsite burial	Not applicable

a. Sources: Snider (1993); Brown (1994c).

b. 1992 data.

c. Includes 649,429 kg of contaminated scrap metal.

d. N/A = not applicable.

e. West End Treatment Facility and Central Pollution Control Facility.

f. 1991 data.

g. Includes contaminated scrap metal.

h. Does not include 6.9 acre scrap metal storage site.

Table 4.14-5. (continued)

i. NPDES discharge limit for the ORNL Non-rad Wastewater Treatment Facility.

j. Includes scrap metal only. Does not include low-level radioactive waste solid sludge from Process Waste Treatment Facility, or from Sanitary Wastewater Treatment Plant.

k. Solid Waste Storage Area.

Table 4.14-6. Baseline low-level waste management activities as of 1995 at the ORR.[a]

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Low-level[b]	9720-12	Low-level waste storage		
			Indoor area	465 m^2	Not accepting waste
			Outside area	557 m^2	139 m^2
		9720-44	Low-level waste storage pad	Not reported	Not reported
		9825-1, 2	Uranium oxide storage vaults I and II	906 m^3 (each vault)	544 m^3 (each vault)
		None	Contaminated scrap metal storage area	Not reported	5% of area available
		None	Outside low-level waste storage	359 m^3	Not reported
		None	Above grade low-level waste storage facility	3,948 m^2	3,553 m^2
		9720-25	Classified waste storage facility	340 m^3	170 m^3
		None	Containerized waste storage area (dual use/storage)	2,323 m^2	929 m^2
K-25 Site	Low-level[c]	K-770	Contaminated scrap metal storage yard	31,857 m^3	2,230 m^3
		K-1035-A	Temporary drum storage	2.5 m^3	Varies
		K-1066-H	LLW[d] storage	3,830 m^3	627 m^3
		K-1417	Sludge-drum storage yard	8,846 m^3	Facility full
		RUBB-2	LLW[d] storage	138 m^3	83 m^3
		K-25	Process vaults (dual storage/use facility)	2,469 m^3	837 m^3
		K-33	Waste piles (dual storage/use facility)	961 m^3	24 m^3
		K-1232	Container storage area (dual storage/use facility)	42.5 m^3	34 m^3

Table 4.14-6. (continued)

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
ORNL	Low-level[b]	7831	Waste compaction facility	Not applicable (treatment facility)	Not applicable (treatment facility)
		7841	Contaminated equipment storage yard	Not reported	Scheduled to undergo closure under RCRA[e]
		7856	Cask storage site	Not reported	Not reported
		7823A, B, C, D, E	RUBB buildings	Not reported	Not reported
		7824	Waste examinations and assay facility, dual use facility	Not available	Not available
		7879	CH-TRU[f]/LLW[d] solids storage facility (dual storage facility)	372 m^2	Facility full
		7842	SWSA-6[g] staging and equipment building	297 m^2	Not applicable Facility is a staging area
		None	Tumulus I and II	Not reported	Facilities undergoing closure

a. Sources: PAI Corporation (1993b); PAI Corporation (1994); PAI Corporation (1993a); Turner (1994).

b. 1993 data.

c. 1994 data.

d. LLW = Low-level (radioactive) waste.

e. RCRA = Resource Conservation and Recovery Act.

f. CH-TRU = Contact-handled transuranic waste.

g. SWSA-6 = Solid Waste Storage Area - 6.

Table 4.14-7. Projected 1995 hazardous waste management activities at the ORR.[a]

Complex	Waste category	Generation rate	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Hazardous solid[b]	511,421 kg[c] (846 m^3/yr)	None	Not applicable	Staged for shipment	4,741 m^3 [d]	Offsite	Not applicable
	Hazardous liquid[b]	767,874 kg[e] (215,492 gal/yr)	Settlement and filtration	See low-level liquid	Tanks	670 yd^3 [f] (136,000 gal)	Offsite	Not applicable
K-25 Site	Hazardous liquid[g]	8,410.6 m^3 [b]	Neutralization/ precipitation	See mixed	Stored for processing	Not applicable	Planned offsite	Not applicable
	Hazardous solid[g]	680.5 m^3	Compaction for non-RCRA/TSCA[i] incineration	Offsite	Onsite	See mixed	Planned offsite	Not applicable
ORNL	Hazardous liquid[g]	0.8 m^3	Neutralization/ detonation	Not applicable	Tanks	588.7 m^3	Offsite	Not applicable
	Hazardous solid[g]	84.1 m^3 [j]	None	Not applicable	Staged for shipment	23,375 gal[k]	Planned onsite/offsite	Planned

a. Sources: Snider (1993); Brown (1994c).

b. 1992 data.

c. Includes 420,192 kg of uncontaminated (radionuclides) asbestos/beryllium oxide (BeO) waste and 42,434 kg of uncontaminated polychlorinated biphenyl waste.

d. Remaining West End Tank Farm sludge storage capacity.

e. Includes 55,624 kg of uncontaminated (radionuclides) polychlorinated biphenyl waste.

f. Liquid Organic Waste Storage Facility OD3, Building 9418-9, and OD9.

Table 4.14-7. (continued)

g. 1991 data.

h. Hydrogen softener blowdown from the steam plant.

i. RCRA = Resource Conservation and Recovery Act; TSCA = Toxic Substances Control Act.

j. Includes polychlorinated biphenyls and asbestos.

k. Hazardous Waste Storage Facility.

Table 4.14-8. Baseline hazardous waste management activities as of 1995 at the ORR.[a]

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Hazardous[b]	None	Interim reactive waste treatment area (open burning)	Not applicable	Not applicable
		9720-45	Organic liquid storage facility	Two 3,000-gal tanks Four 6,500-gal tanks 1,000, 55-gal drums	Variable
		9720-9	Mixed and PCB[c] storage area (dual storage/use)	311 m^3	62 m^3
		9720-31	RCRA[d] staging and storage facility (dual storage/use)	37,000 gallons	9,250 gallons
		9720-58	RCRA[d] and PCB[c] container storage area (dual storage/use)	Not reported	Not reported
		9811-1	Waste oil tank storage Area OD-7 (dual storage/use)	Two 30,000-gal tanks One 10,000-gal tank Two 3,000-gal tanks	38,000 gallons
		9811-8	Waste oil solvent drum storage facility, OD-8 (dual storage/use)	1,000 55-gal drums/containers	Not reported
		9811-8	Organic liquid storage area, OD-9 (dual storage/use)	Five 40,000-gal tanks Thirty-five 55-gal drums	50,480 gallons (projected to be used until the year 2010)
		9404-7	PCB[c] storage facility	334 m^2	84 m^2
		None	East Chestnut Ridge Waste Pile (dual use/storage facility)	Not reported	Not reported
K-25 Site	Hazardous/ mixed	K-25	Process vaults (dual storage/use facility)	6,810 m^3	1,282 m^3
		K-711	Container storage building (dual storage/use facility)	234 m^3	188 m^3
		K-1025C	Container storage (dual storage/use facility)	7 m^3	1 m^3
		K-1036A	Container storage facility (dual storage/use facility)	134 m^3	44 m^3

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Table 4.14-8. (continued)

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
		K-1202	Storage tanks (dual storage/use facility)	108 m^3	76 m^3
		K-1302	Compressed gas cylinder storage (dual storage/use facility)	0.6 m^3	Facility full
		K-1420A	Hazardous waste storage tank (dual storage/use facility)	108 m^3	108 m^3
		K-1425	Container storage/tank management units (dual storage/use facility)	529 m^3	357 m^3
		K-726	Container storage building (dual storage/use facility)	86 m^3	Facility full
		K-33	TSCA[f] (dual storage/use facility)	961 m^3	24 m^3
	Hazardous[b]	7659-A	Gas cylinder venting facility	Not applicable (venting facility)	Not applicable
ORNL		7667	Chemical waste detonation facility	Not applicable (treatment facility)	Not applicable (treatment facility)
		7507	PCBs[g], liquids and solids storage facility	31 m^3	Facility full
		7651	Used oil storage facility	27 m^3	13 m^3
		7652	Hazardous waste storage facility	57 m^3	8.5 m^3
		7653	Chemical waste storage facility	60 55-gal drums	9 55-gal drums

a. Sources: PAI Corporation (1993b); PAI Corporation (1994); PAI Corporation (1993a).

b. 1993 data.

c. PCB = Polychlorinated biphenyl.

Table 4.14-8. (continued)

d. RCRA = Resource Conservation and Recovery Act.

e. 1994 data.

f. TSCA = Toxic Substances Control Act.

g. PCB = Polychlorinated biphenyl.

Table 4.14-9. Projected 1995 industrial solid waste management activities at the ORR.[a]

Complex	Waste category	Generation rate[b]	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Industrial solid[b]	5,554,873 kg (48,518 m^3/yr)	None	N/A	None	N/A	Landfill (onsite)	5.3522M[c] m^3[d]
K-25 Site	Industrial solid[e]	3,899.5 m^3	None	Not applicable	None	Not applicable	Y-12 landfill	5.3522M[c] m^3[f]
	Other solid[e]	5,046.4 m^3[g]	Compaction	Not applicable	None	Not applicable	Y-12 landfill	See industrial solid
ORNL	Industrial solid[e]	13 m^3	None	Not applicable	None	Not applicable	Y-12 landfill	5.3522M[c] m^3[f]
	Other solid[e]	30.6 m^3[h]	None	Not applicable	None	Not applicable	Y-12 landfill	See industrial solid

a. Sources: Snider (1993); Brown (1994c); PAI Corporation (1994); PAI Corporation (1993a).

b. 1992 data.

c. M = million

d. New sanitary landfill to open in 1994.

e. 1991 data.

f. Wastes are disposed of at the Y-12 Plant Sanitary Landfill.

g. Includes construction/demolition spoil and scrap metal.

h. Includes construction/demolition spoil; scrap metal estimates not available.

Table 4.14-10. Baseline industrial solid waste management activities as of 1995 at the ORR.[a,b]

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Industrial solid	None	New salvage yard	4,046.9 m^2	1,619 m^2
		None	Industrial landfill IV (classified waste landfill)	Not reported	Estimated useful life of the landfill is until the year 2034
		9983-44	Industrial landfill II	Storage capacity depleted	Storage capacity depleted
		None	Spoil Area 3 (construction debris)	Facility closed	Facility closed
		9720-25	Classified waste storage (dual use facility)	Not applicable (nonhazardous solid waste staging area)	Not applicable
K-25 Site	Industrial solid[c]				
ORNL	Industrial solid[c]				

a. Source: PAI Corporation (1993b).

b. 1993 data.

c. Wastes are disposed of at the Y-12 Plant Sanitary Landfill.

In addition, diesel fuel and gasoline, used to fuel site service and construction vehicles, are stored in bulk containers (55-gallon drums, aboveground storage tanks, and underground storage tanks).

The Y-12 Plant underground storage tank program includes seven in-service petroleum tanks. In addition, there are seven active petroleum underground storage tanks at the K-25 Site. At the ORNL there is one active underground storage tank containing heating oil and 22 active underground storage tanks that will be taken out of service or upgraded by 1998. The contents of these tanks was not reported (MMES 1993a).

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5. ENVIRONMENTAL CONSEQUENCES

5.1 Overview

This chapter describes the potential environmental consequences from the construction and operation of spent nuclear fuel (SNF) facilities at the Oak Ridge Reservation (ORR) under the Centralization and Regionalization Alternatives. Potential environmental consequences are assessed to the extent necessary to support a programmatic decision concerning the siting of the proposed SNF facilities. More detailed considerations of potential environmental consequences would be performed as necessary prior to initiating construction or operation of the facilities.

Impacts on the operation of the current facilities at ORR that create or store SNF are discussed in Chapter 3.

5.2 Land Use

The proposed site for SNF activities is in the eastern portion of the West Bear Creek Valley area, located in the western portion of the ORR. The SNF program's land requirements are assumed to be 90 acres (0.36 square kilometer), including all facilities and buffer areas. The majority of the land in the West Bear Creek Valley Area can be characterized as vacant, unused, and developable.

5.2.1 Centralization Alternative

Use of the West Bear Creek Valley area of the ORR for program activities would be consistent with the current land use and land use policies and plans for that area. The current land use designation for this area is Natural Areas, a generic category that includes all lands within the ORR not under any other specific land use designation (DOE 1993a). Use of this area for program activities would also be consistent with proposed future land uses as set forth in the ORR Site Development Plan (MMES 1989).

Future land uses proposed for the area of Roane County adjacent to the ORR near the proposed SNF site are low-density residential and public/semi-public uses (Roane County Regional Planning Commission 1992). These low intensity uses would be compatible with development in the western portion of the ORR.

Use of the West Bear Creek Valley site for the placement of SNF facilities may result in irreversible and irretrievable impacts to land use in that area by precluding all but waste management-type uses in the future. However, the placement of SNF facilities at this location would be consistent with U.S. Department of Energy's (DOE's) 1994 future land use plan, which designates the West Bear Creek Valley site for these uses (MMES 1989). Therefore, no mitigation measures are proposed.

5.2.2 Regionalization Alternative

As under the Centralization Alternative, land use impacts resulting from the Regionalization Alternative would not be expected to be significant. Impacts would be similar in character to those described for the Centralization Alternative.

5.3 Socioeconomics

Socioeconomics as addressed in this programmatic environmental impact statement (EIS) encompasses the interaction of economic, demographic, and social conditions. Economic consequences (e.g., technology requirements for operation of an SNF management facility) affect business activities, market structures, procurement methods, and dissemination of commodities within and between regions. Demographic consequences (e.g., in-migration of specialized human resources to support the SNF management program) affect size, distribution, and composition of the population, labor force, and the housing market in the regions. Social consequences (e.g., capacity modifications of public infrastructure to support SNF activity) affect the overall quality of life enjoyed by the residents of a community (Murdock and Leistritz 1979). These conditions are potentially affected either directly or indirectly by actions proposed under the DOE SNF Management Program.

The significance of actions and their intensity are relative to the affected region. A region can be described as a dynamic socioeconomic system, where physical and human resources, technology, social and economic institutions, and natural resources interrelate to create new products, processes, and services to meet consumer demands. The measure of a region's ability to support these demands depends on its ability to respond to changing economic, demographic, and social conditions.

Potential socioeconomic effects are addressed only to the extent that they are interrelated with the natural or physical environment (CFR 1993c). Direct effects include those impacts caused by the action and occurring at the same time and place. Indirect effects include those impacts caused by the action that are later in time or farther removed in distance, but are still reasonably foreseeable (i.e., offsite) (CFR 1993b).

Socioeconomic effects are quantified for regional economic activity and population. Potential impacts to individual communities such as public infrastructure and housing are discussed qualitatively to address programmatic issues.

Economic projections include direct and indirect jobs. Direct jobs are those jobs needed to construct or support operation of the SNF management complex at ORR. Indirect jobs are created throughout the regional economy within the Region of Influence as a result of procurement for materials, services, and other commodities; and induced effects from consumer spending. These direct and indirect impacts reflect both construction and operation phase demands that may occur concurrently or independently throughout the project planning period. Indirect jobs were projected using parameters from the U.S. Bureau of Economic Analysis Regional Input-Output Modeling System.

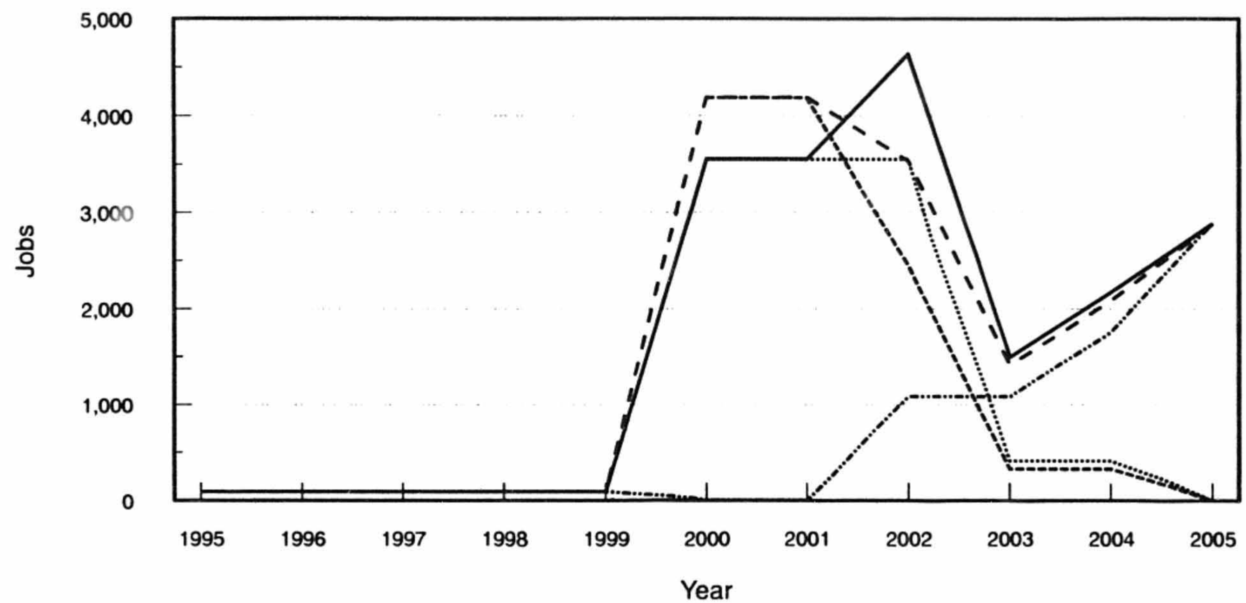
Two scenarios were analyzed to account for two potential distributions of the SNF facility construction efforts. The construction effort consists of fabricating various structures, each with its own construction labor need and a duration of either three or five years. The Peak Scenario accelerates the construction labor requirements into the first two years of construction. The Average Scenario averages the labor requirements of a structure for the duration of construction. The total construction effort for all structures, in labor years is the same for each scenario.

Therefore, for structures with a three year construction duration, the Peak Scenario has high labor needs for the first two years and then a substantial reduction for the third year, while the Average Scenario has a constant labor requirement for the three years. Likewise, for structures with a five year construction duration, the Peak Scenario has a high labor need for the first two years, then a lower need for the remaining three years, while the Average Scenario has a constant requirement for all five years. Because the total construction labor years for each structure is the same for both scenarios, the Average Scenario will have a lower requirement than the Peak Scenario in the first two years, then will have a higher requirement then the Peak Scenario in the remaining construction years.

Regional population projections reflect the potential change in population resulting from an increase in regional economic activity. Detailed assumptions regarding in-migration associated with SNF Management Program were not developed given the programmatic scope of the analysis. Potential in-migration effects resulting from direct job creation are presented qualitatively where appropriate.

5.3.1 Centralization Alternative

The upper and lower bounds of construction and operations related jobs generated from implementation of the Centralization Alternative from 1995 to 2005 are illustrated in Figure 5.3-1 and tabulated in Table 5.3-1. In the initial phases, the Centralization Alternative may create 90 jobs (25 direct, 65 indirect) beginning in 1995 and continuing through the year 1999 to support project planning, engineering design, and environmental permitting and compliance. Construction is expected to begin in the year 2000, requiring a total of 4,352 direct jobs (7,1232 indirect jobs). In that year and 2001, the Peak Scenario requires 1,587 construction laborers, while the Average Scenario needs 1,346. There is no operational labor required for this time period. In 2002 after two years of construction, the Peak Scenario decreases its construction labor requirements to 928 workers, while the Average Scenario maintains its 1,346 laborers. Additionally, 300 operational personnel are needed, raising the total of SNF workers to 1,228 for the Peak Scenario and 1,646 for the Average Scenario. By 2003, the buildings with three year construction durations have been completed; therefore, both the Peak and Average Scenario construction labor requirements decline to 125 and 157, respectively. Operation labor



1. Effects are direct and indirect.
2. Peak Scenario assumes construction labor peaks in the initial years of construction activity.
3. Average Scenario assumes construction labor is averaged throughout construction period.

= Total Employment - Average Scenario
= Total Employment - Peak Scenario
= Construction - Average Scenario
= Construction - Peak Scenario
= Operations

Figure 5.3-1. Total employment effects - ORR Centralization Alternative

Table 5.3-1. Socioeconomic effects - Centralization of SNF at Oak Ridge Reservation.

	Time period					
Years	1995-1999	2000, 2001	2002	2003	2004	2005 +
			Operations			
Direct jobs	25	0	300	300	487	800
Indirect jobs	65	0	780	780	1,265	2,079
Total jobs	90	0	1,080	1,080	1,752	2,879
			Construction			
Direct jobs						
Peak	0	1,587	928	125	125	0
Average	0	1,346	1,346	157	157	0
Indirect jobs						
Peak	0	2,597	1,519	205	205	0
Average	0	2,203	2,203	257	257	0
Total jobs						
Peak	0	4,184	2,447	330	330	0
Average	0	3,549	3,549	414	414	0
			Total			
Direct jobs						
Peak	25	1,587	1,228	425	612	800
Average	25	1,346	1,646	457	644	800
Indirect jobs						
Peak	65	2,597	2,299	984	1,470	2,079
Average	65	2,203	2,983	1,036	1,522	2,079
Total jobs						
Peak	90	4,184	3,527	1,408	2,082	2,879
Average	90	3,548	4,629	1,493	2,166	2,879
			Population Change			
Peak	82	4,366	(1,001)	(3,214)	1,022	2,011
Average	82	3,688	1,640	(4,759)	1,022	1,797

requirements remain at 300 workers. Total SNF labor requirements are 425 workers for the Peak Scenario and 457 for the Average Scenario. In 2004, construction labor needs for both scenarios remains at their previous level, but operational personnel increase. Total SNF labor requirements are 612 workers in the Peak Scenario and 644 workers in the Average Scenario. By 2005, all construction has been completed and operational personnel have increased to the full staff labor requirement of 800 workers.

The peak scenario reaches it maximum construction labor with 1,587 direct jobs (4,184 total jobs created) over a 2-year period from years 2000 through 2001. The average scenario would have its maximum construction labor with 1,346 direct jobs (3,549 total jobs created) from 2000 through 2002.

Ancillary operation (Table 5.3-1) activity associated with the Centralization Alternative will begin in the year 2002; the initial operations might create approximately 1,080 phase-related jobs (300 direct, 780 indirect). Additional operation activity would also begin, creating an additional 187 phase-related jobs (485 indirect jobs). The remaining operation activities are expected to start in 2005, after construction is finished, creating a total of 2,879 phase-related jobs (800 direct, 2,079 indirect), and the jobs will continue through 2035.

Regional businesses and the workforce will benefit from increased competition for contract procurements and jobs associated with SNF Centralization Alternative. Most of this activity is anticipated to be captured by Anderson, Knox, and Roane counties, with a small share occurring in Loudon County. The impact to the regional economy, however, only represents a portion of the total economic activity generated by the Centralization Alternative. For instance, specialized materials purchases and technology acquisition may occur outside Tennessee. The economic activity occurring outside the region might result in economic benefits for that region. This indirect effect is not captured by this analysis since it occurs outside of the Region of Influence as defined in Section 4.3.

Most of the population change in the Region of Influence above the baseline forecast will be driven by the in-migration of labor and households to support SNF management activities at

ORR. It is likely that most of the operation jobs will be filled by SNF personnel relocating from other DOE sites where SNF inventories were stored prior to shipments to ORR. These personnel would be familiar with the processes, technologies, and research involved with SNF operations elsewhere. Other operational jobs not associated with SNF management will probably be filled by the regional labor force. The regional labor force would be likely to fill the demand for construction jobs, except for specialized tasks.

To assess potential population and housing impacts, an in-migration rate per job was estimated using a ratio between forecasted employment and population figures (Table 4.3-1). This ratio was applied to the number of total (direct and indirect) jobs created by SNF management activities at ORR, giving the total estimated number of persons migrating into the Region of Influence per job created (Table 5.3-1).

With initial operation in 1995 under both scenarios, a total of 82 persons will migrate into the Region of Influence. The number of persons migrating into the Region of Influence would be at its largest when construction starts, for the years 2000 through 2001; (a total of 4,366 in-migrants for the peak scenario and 3,688 for the average scenario). For the years 2002 and 2003, after most of the construction has finished, people might migrate out of the Region of Influence. The number of in-migrants might increase as more of the SNF management operations start in the years 2004 and 2005. After the year 2005, in-migration due to SNF management activities would cease due to the fact that SNF management activities would not create any more jobs.

Assuming one housing unit per household, and an average family size of 2.6 persons per family (U.S. Department of Commerce 1991), the number of houses demanded in 1995, when preliminary operations start, might be 32. Between the year 2000 and 2002, a total of 1,679 housing units might be demanded. Even though this demand is only a temporary demand, the Region of Influence may have difficulty providing new housing during this time period. By the year 2003 and 2004, however, there might be a surplus of 1,236 housing units due to the phasing out of construction. In 2005, once SNF operational activities are under way, there will be a demand for 1,167 housing units associated with SNF management activities.

The greatest impact to the Region of Influence housing market may occur between the years 2000 and 2002, when construction starts. The demand for housing during the SNF facility construction period would be for transitional housing. While the population in the Region of Influence under baseline conditions has historically been growing and is projected to grow at less than 1 percent annually, recent vacancy rates for housing in the Region of Influence have been low (Census 1982, 1991). Therefore the in-migration associated with SNF construction might cause shortages in the housing market, and might cause shortages in construction supplies. However, due to decreasing employment levels on ORR between 1990 and 1999 (Section 4.3.1.5), additional housing units above the baseline may be available, thus reducing the potential strain on the housing market. Since construction will only be temporary, there may be excess capacity in the regional infrastructure when all SNF management operations begin in 2005.

5.3.1.1 Potential Public Service and Education Impacts. Given the population growth associated with the SNF Management Program, increases in capital expenditure may be required to meet the increased demand of housing utilities, including electricity generation, wastewater treatment, and water (see Section 5.13), transportation infrastructure (see Section 5.11), and education or service levels, assuming current conditions are constant through the analysis.

Assuming that the Centralization Alternative would be an addition to the ORR's current operations, security and fire protection on the site would need to be investigated at a minimum to determine whether or not current capacity could accommodate the requirements of the SNF Management Program.

5.3.2 Regionalization Alternative

Socioeconomic impacts resulting from the Regionalization Alternative are expected to be similar to the Centralization Alternative. The construction and operation cycles for each alternative would be the same; therefore, the same issues identified for the Centralization Alternative would apply. Labor requirements may be slightly reduced for the Regionalization Alternative. Although the volume of SNF stored would be less for the Regionalization Alternative, an economy of scale occurs for both alternatives, so that differences in labor and capital between the two alternatives would be minimized.

5.3.3 Mitigation Measures

5.3.3.1 Coordination with Local Jurisdictions. To reduce construction- and operation-related impacts, possible coordination with local communities could address potential impacts from increased labor and capital requirements. The knowledge of the extent and effect of growth due to SNF management activities could greatly enhance the ability of affected jurisdictions to plan effectively. Effective planning would address changes in levels of service for housing, infrastructure, utilities, transportation, and public services and finances.

5.3.3.2 Enhance Labor Force Availability. To alleviate potential impacts associated with the in-migration of labor, local labor force availability could be increased through various employment training and referral systems. The goal of these systems would be to reduce the potential for in-migration of labor to support SNF management activities.

5.4 Cultural and Paleontological Resources

5.4.1 Centralization Alternative

Under the Centralization Alternative, the proposed construction area for the SNF facilities is not expected to exceed 100 acres. There are no known historical, archeological, paleontological or Native American traditional sites in the proposed area (Fielder 1975). No impacts to cultural or paleontological resources are expected due to ground disturbance, noise, or air emissions during construction or operation of the SNF facilities. Consultation with the Tennessee State Historic Preservation Officer prior to project implementation is required by section 106 of the National Historic Preservation Act.

5.4.2 Regionalization Alternative

Under the Regionalization Alternative, the location of the SNF facilities would remain the same, but would be reduced in area. As with the Centralization Alternative, impacts are not anticipated.

5.5 Aesthetics and Scenic Resources

5.5.1 Centralization Alternative

When fully constructed and under operation, the proposed SNF facilities associated with the Centralization Alternative would consist of a series of buildings set within a 90-acre site. The maximum height of the buildings contained at the site would not exceed 42 feet above ground level, or two to three stories. The entrance to the site and security fencing will be visable to traffic on Bear Creek Road.

Since the buildings would be set into the south face of Pine Ridge, between Pine Ridge and Chestnut Ridge, the site would not be visible from areas outside the reservation, with the possible exception of a limited section of Gallaher Road on the west side of the Clinch River, looking east along Bear Creek Valley (TVA 1987). However, since the approximate distance from the boundary of the reservation to the proposed location is in excess of 2 miles, and includes hilly terrain and heavy vegetation, public views looking on to the site from off-site are not expected to be affected. Impacts to aesthetics and scenic resources on and off ORR are not anticipated.

5.5.2 Regionalization Alternative

Under the Regionalization Alternative, proposed SNF facilities are reduced in area and intensity of operations, and environmental effects to aesthetics and scenic resources would be less than those under the Centralization Alternative. Therefore, adverse environmental impacts from the Regionalization Alternative are also not anticipated.

5.6 Geologic Resources

This section describes any incremental or additional impacts on geology and geologic resources that might result from the construction and operation of the new facilities associated with the storage of SNF at the ORR.

For the most part, geologic impacts from construction activities would be limited to soil disturbance, although in some areas, ripping or blasting of limestone, dolomite, or chert layers might be required. Since no extensive or unique geologic or mineral resources are known to occur on the West Bear Creek Valley site, impacts to geologic resources would not be expected.

Because previously undisturbed areas would be used for new construction, some soil impacts from siting SNF facilities at the West Bear Creek Valley site would occur as a result of grading. Potential impacts from sediment runoff generated during construction activities would be minimized by implementation of soil erosion and sediment control measures. During operations, impacts to soil resources would be controlled by the planting or landscaping of land surfaces not covered by pavement and buildings.

Major seismic activity and associated mass movement and subsidence are unlikely to occur during the construction or operation phases, because although ground-shaking has occurred at the ORR due to earthquakes in other parts of the country, faults in the area have not been active since the late Paleozoic.

5.7 Air Resources

The proposed SNF management facility would be composed of a wet and dry storage facility and a technology development facility, with construction to take place in the calendar years 2000-2004. Air quality is assessed for construction and operation with regard to radiological and nonradiological air emissions. This section characterizes the impacts and expected air quality effects resulting from an SNF facility. This section also discusses the quantitative impacts under the Regionalization Alternative. The Centralization Alternative qualitative impacts are compared with the regionalization impacts in order to determine exceedances, if any, of existing local and Federal standards for both alternatives.

5.7.1 Releases

Emissions of radiological and nonradiological air pollutants might result from the construction and operation of a SNF management facility. These emissions might include airborne radionuclides, criteria pollutants, and hazardous air pollutants.

The impact of air emissions from construction activities might include criteria air pollutants of particulate matter (fugitive dust) primarily from the moving of soil, and exhaust emissions of particulate matter with an aerodynamic diameter equal to or less than 10 microns (PM_{10}); carbon monoxide; sulfur dioxide; volatile organic compounds; and nitrogen dioxide from earth-moving and equipment-handling machinery and equipment. During construction, a small increment in traffic volume above existing levels might result in a small increase in air pollutant emissions. (Section 5.11 discusses the level of traffic activity projected for the construction and operation phases of the SNF facility.)

During operations, the transport of SNF within the ORR from points of generation or storage sites to the disposal site would result in emissions of criteria air pollutants from various vehicles as well. Some emissions of air pollutants from worker vehicles would also occur both within and beyond the ORR.

5.7.1.1 Radiological Emissions. There are no expected contributions to radiological air emissions during the construction phases of the proposed SNF management facility. During operations, the facility would be expected to generate negligible radiological emissions. The potential radiological emissions associated with the proposed SNF management facility and those associated with the baseline are presented in Table 5.7-1 by isotope.

5.7.1.2 Nonradiological Emissions. The construction phase of the SNF facility for the Receipt/Storage Facility and Canning Factory is estimated to be complete in about 8-10 years. Short-term emissions, such as fugitive dust and heavy equipment exhaust emissions, would be generated temporarily, and would only affect receptors close to construction areas. Fugitive dust emissions would be minimized by watering. Under the operational phase of the SNF management facility, criteria and hazardous air pollutants might be emitted. Table 5.7-2 lists

Table 5.7-1. Isotopic release additions due to SNF management facility presence (Ci/yr) at ORR.[a]

	(Baseline) ORR	(SNF) ISF	ORR + ISF
Hydrogen-3	2.1×10^{3}	7.9×10^{-1}	2.1×10^{3}
Beryllium-7	8.9×10^{-6}	0.0×10^{0}	8.9×10^{-6}
Carbon-14	0.0×10^{0}	1.2×10^{0}	1.2×10^{0}
Potassium-40	1.0×10^{-3}	0.0×10^{0}	1.0×10^{-3}
Manganese-54	0.0×10^{0}	2.2×10^{-8}	2.2×10^{-8}
Cobalt-60	3.0×10^{-5}	4.2×10^{-8}	3.0×10^{-5}
Bromine-82	1.0×10^{-5}	0.0×10^{0}	1.0×10^{-5}
Krypton-83M	7.3×10^{1}	0.0×10^{0}	7.3×10^{1}
Krypton-85	0.0×10^{0}	1.0×10^{4}	1.0×10^{4}
Krypton-85M	1.7×10^{2}	0.0×10^{0}	1.7×10^{2}
Krypton-87	3.5×10^{2}	0.0×10^{0}	3.5×10^{2}
Krypton-88	4.9×10^{2}	0.0×10^{0}	4.9×10^{2}
Krypton-89	6.3×10^{2}	0.0×10^{0}	6.3×10^{2}
Strontium-90	1.2×10^{-4}	3.3×10^{-6}	1.2×10^{-4}
Yttrium-90	1.2×10^{-4}	3.3×10^{-6}	1.2×10^{-4}
Technetium-99	6.1×10^{-2}	0.0×10^{0}	6.1×10^{-2}
Ruthenium-106	4.4×10^{-4}	1.1×10^{-5}	4.5×10^{-4}
Antimony-125	0.0×10^{0}	3.4×10^{-4}	3.4×10^{-4}
Iodine-129	3.1×10^{-4}	1.0×10^{-1}	1.0×10^{-1}
Iodine-131	1.2×10^{-1}	0.0×10^{0}	1.2×10^{-1}
Iodine-132	1.4×10^{0}	0.0×10^{0}	1.4×10^{0}
Iodine-133	6.5×10^{-1}	0.0×10^{0}	6.5×10^{-1}
Iodine-134	2.1×10^{-2}	0.0×10^{0}	2.1×10^{-2}
Iodine-135	1.2×10^{0}	0.0×10^{0}	1.2×10^{0}
Xenon-133	8.8×10^{2}	0.0×10^{0}	8.8×10^{2}
Xenon-133M	2.7×10^{1}	0.0×10^{0}	2.7×10^{1}
Xenon-135	2.8×10^{1}	0.0×10^{0}	2.8×10^{1}
Xenon-135M	1.6×10^{2}	0.0×10^{0}	1.6×10^{2}
Xenon-138	8.5×10^{2}	0.0×10^{0}	8.5×10^{2}
Cesium-134	6.3×10^{-7}	6.2×10^{-8}	6.9×10^{-7}
Cesium-137	7.0×10^{-4}	4.8×10^{-5}	7.5×10^{-4}
Cesium-144	1.2×10^{-6}	0.0×10^{0}	1.2×10^{-6}

Table 5.7-1. (continued).

	(Baseline) ORR	(SNF) ISF	ORR + ISF
Barium-140	1.0×10^{-4}	0.0×10^{0}	1.0×10^{-4}
Lanthanum-140	1.4×10^{-6}	0.0×10^{0}	1.4×10^{-6}
Europium-152	4.4×10^{-11}	0.0×10^{0}	4.4×10^{-11}
Europium-154	5.9×10^{-6}	0.0×10^{0}	5.9×10^{-6}
Europium-155	3.0×10^{-6}	0.0×10^{0}	3.0×10^{-6}
Osmium-191	2.3×10^{-2}	0.0×10^{0}	2.3×10^{-2}
Lead-212	1.6×10^{0}	0.0×10^{0}	1.6×10^{0}
Thorium-228	1.5×10^{-3}	0.0×10^{0}	1.5×10^{-3}
Thorium-230	7.4×10^{-4}	0.0×10^{0}	7.4×10^{-4}
Thorium-232	3.0×10^{-5}	0.0×10^{0}	3.0×10^{-5}
Protactinium-234	1.2×10^{-3}	0.0×10^{0}	1.2×10^{-3}
Uranium-234	7.2×10^{-2}	0.0×10^{0}	7.2×10^{-2}
Uranium-235	2.6×10^{-3}	0.0×10^{0}	2.6×10^{-3}
Uranium-236	1.9×10^{-4}	0.0×10^{0}	1.9×10^{-4}
Uranium-238	4.1×10^{-2}	0.0×10^{0}	4.1×10^{-2}
Neptunium-237	1.1×10^{-4}	0.0×10^{0}	1.1×10^{-4}
Plutonium-238	6.1×10^{-4}	0.0×10^{0}	6.1×10^{-4}
Plutonium-239	1.3×10^{-4}	0.0×10^{0}	1.3×10^{-4}
Plutonium-240	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Americium-241	1.4×10^{-5}	0.0×10^{0}	1.4×10^{-5}
Curium-244	2.0×10^{-4}	0.0×10^{0}	2.0×10^{-4}

a. Source: Johnson, V. (1994).

Cm241 with 35 day half-life included with AM241 with 458 yr half-life.
Os194 with 8.0 yr half-life decays to Ir194 with 17.4 hr half-life, then to P1194 which is stable.
ISF: Interim Storage Facility.

Table 5.7-2. Total annual nonradioactive emissions for the SNF management facility at ORR.[a]

Criteria pollutants	Release rate (kg/yr)
Carbon monoxide	1.7×10^{3}
Particulate matter, PM_{10}[b]	1.0×10^{-3}
Nitrogen oxides	5.5×10^{3}
Sulfur dioxide	1.3×10^{2}
Lead	5.0×10^{-9}
Hazardous air pollutants	
Selenium compounds	1.6×10^{-4}
Mercury compounds	5.1×10^{-1}
Chlorine	3.5×10^{3}
Hydrogen fluoride	1.6×10^{1}
Cadmium compounds	2.9×10^{-7}
Cobalt, chromium, antimony, and nickel compounds	2.0×10^{-10}

a. Source: Johnson, V. (1994).

b. It is assumed that PM_{10} (particulate matter less than 10 microns in diameter) data are total suspended particulate data.

total expected annual emissions associated with the SNF storage facility. These nonradioactive emissions are primarily from the technology development facility and were estimated based on a previous design for a similar facility proposed at INEL.

5.7.2 Air Quality

5.7.2.1 Radiological. The GENII Environmental Transport and Dose Assessment Model, along with 1992 Y-12 west meteorological data and 1992 source terms (Table 5.7-1), was used to calculate the effective dose equivalent for the year 2005. A population of 988,754 persons within 80 kilometers (50 miles) is estimated. A radiation background level of 306 millirem per year is used.

Based on model results, 1 year of operation at the SNF management facility might result in a calculated dose of 9.5 millirem per year to the maximally exposed member of the public. This dose is below the National Emission Standards for Hazardous Air Pollutants limit of 10 millirem per year and is 3.1 percent of the natural background radiation received by the average person near the ORR.

The annual population dose from operation in the year 2005 was calculated to be 5.7×10^{1} person-rem. The population dose from operation of this option in 2005 is approximately 2.1×10^{-2} percent of the dose received by the surrounding population from natural background radiation.

Table 5.7-3 summarizes the effective dose equivalents for the maximum boundary dose and to the population with 80 kilometers (50 miles) of the proposed SNF facility. Compared to the background radiation, these increased doses are very small. The total doses are well within the regulatory limits.

5.7.2.2 Nonradiological. The Industrial Source Complex Short-Term Air Dispersion model was used with 1992 meteorological data from the Y-12 west meteorological monitoring station at ORR to determine pollutant concentrations resulting from the centralization portion of nonradiological emissions listed in Table 5.7-2. An emissions baseline was established to

Table 5.7-3. Summary of effective dose equivalents to the public from ORR operations and the proposed SNF management facility.

	Maximally exposed individual dose[a]	Collective dose to population within 80 km of ORR sources
Dose	9.5 mrem per year[b]	5.7×10^{1} [c]
Location	Site boundary 1.2 km SW of ORR storage facility	9.1×10^{5} people within 80 km of SNF storage facility
NESHAP[b] standard	10 mrem per year	—
Percentage of NESHAP	95	—
Natural background dose	306 mrem	2.79×10^{5} person-rem
Percentage of natural background dose	3.1	2.1×10^{-2}

a. The maximum boundary dose is the hypothetical individual exposed continuously during the year at ORR boundary located 1.2 km SW from the SNF site.

b. The SNF management facility contributes 6.2 mrem to this dose.

c. The SNF management facility contributes 5.2 person-rem to this dose.

NESHAP: National Emission Standards for Hazardous Air Pollutants.

km: kilometer

mrem: millirem

Note: Effective dose equivalents computed using GENII (PNL 1988).

characterize conditions at ORR using actual emission rates (MMES 1993a). It is also assumed that 1995 operations at the ORR will result in the same baseline nonradiological emissions as the 1992 operations at the ORR. The results of modeling are presented in Table 5.7-4, where the existing ORR site contribution concentration is compared to the existing DOE site contribution concentration plus the proposed SNF contribution. Table 5.7-5 presents the annual maximum concentration for hazardous air pollutants for offsite receptors. These concentrations are used in Section 5.12 for calculation of health effects. The increases in pollutant concentrations from the proposed action are negligible in magnitude. The concentrations of nonradiological air pollutants from operation of the SNF facilities, under that alternative, and from existing sources would remain within all applicable regulatory guidelines.

If a Regionalization Alternative SNF facility is operated at the ORR, the incremental contribution to maximum concentrations of pollutants would be less than for the Centralization Alternative. The concentrations of nonradiological air pollutants from operation of the SNF facilities, under this alternative, and from existing sources would remain within all regulatory guidelines.

5.8 Water Resources

Construction and operation of SNF management facilities could potentially affect water resources. Potential environmental impacts to surface water and groundwater resources during construction include depletion of water supplies, floodplain encroachment, and surface water sedimentation from erosion runoff occurring after land clearing. Potential normal operational impacts would include depletion of water supplies, and diminished water quality resulting from wastewater discharges from normal operations.

Impacts are analyzed for the Centralization Alternative, which would cause the most impacts to water resources at the ORR, if chosen. However, for the Centralization Alternative, no significant impacts are identified with respect to water resources issues. Therefore, no significant impacts are expected from the Regionalization Alternative as the Centralization Alternative is the bounding case.

Table 5.7-4. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at ORR and proposed SNF management facility plus current operations.

Criteria pollutant	Averaging time	Most stringent regulation or guideline[a] (μg per m^3)	Total existing maximum concentration[b] (μg per m^3)	Total projected maximum concentration including SNF (μg per m^3)	Increase in maximum concentration (μg per m^3)
Carbon monoxide[c]	8-hour	10,000	6.9	6.9	0
	1-hour	40,000	24.1	33.5	9.4
Nitrogen dioxide	Annual	100	2.1	2.7	0.6
Lead	Calendar quarter	1.5	d	3.7×10^{-12}	3.7×10^{-12}
PM_{10}[e]	Annual	50	12.0	12.0	0
	24-hour	150	97.9	97.9	0
Sulfur dioxide	Annual	80	29.29	29.34	0.05
	24-hour	365	177.8	178.0	0.2
	3-hour	1,300	401.5	401.5	0
Total suspended particulates	Annual	50[a]	36.0	36.0	0
	24-hour	150[a]	116.9	116.9	0
Hydrogen fluoride (as fluorides)	30-day	1.2[a]	0.06	0.06	0
	7-day	1.6[a]	0.03	0.03	0
	24-hour	2.9[a]	d	f	f
	8-hour	3.7[a]	d	f	f
Hazardous air pollutants					
Selenium	8-hour	20	d	2.18×10^{-7}	2.18×10^{-7}
Mercury compounds	8-hour	0.5	d	2.18×10^{-3}	2.18×10^{-3}
Chlorine compounds	8-hour	150	d	1.52	1.52
Cadmium compounds	8-hour	5	d	1.81×10^{-9}	1.81×10^{-9}
Cobalt, chromium, antimony, and nickel compounds	8-hour	5	d	5.5×10^{-10}	5.5×10^{-10}

a. State standard.

b. Includes background concentration plus existing DOE facilities impact concentration. This is the baseline concentration.

c. Existing maximum and projected maximum did not occur in the same location.

d. Zero release (no sources indicated).

e. It is assumed that PM_{10} (particulate matter less than 10 microns in diameter) data are total suspended particulate data.

f. Not estimated because the potential release is negligible.

Table 5.7-5. Calculated annual maximum concentrations for hazardous air pollutants at ORR for offsite receptors.[a]

Hazardous air pollutant	Maximum average concentration($\mu g/m^3$)
Selenium compounds	8.85×10^{-8}
Mercury compounds	8.85×10^{-4}
Chlorine compounds	0.62
Hydrogen fluoride	1.53×10^{-3}
Cadmium compounds	7.35×10^{-10}
Cobalt, chromium, antimony and nickel compounds	2.21×10^{-10}

a. Offsite includes public access roads within the ORR. All impacts from proposed source only. No hazardous air pollutant emissions information available for existing sources.

5.8.1 Surface Water Quantity

The ORR currently receives its water supply from the Clinch River basin. Construction and operation of SNF management facilities would have very minimal impact on the quantity of water in the river and in local surface streams.

Construction of SNF management facilities would require some water consumption. However, the amount of water required would not significantly affect the Clinch River water level.

Stormwater runoff associated with both the construction and operation of SNF facilities is expected to have a negligible impact on surface water quantity. During construction, standard stormwater management techniques would be employed to attenuate runoff. A site drainage and stormwater management system consisting of perimeter drainage ditches and a retention pond would be included as part of SNF operations (Johnson, V. 1994). This system would provide for runoff and erosion control, which could otherwise affect receiving water courses or SNF operations.

As discussed in Section 4.8.1, analysis of available data indicates that the proposed SNF management facilities would be sited outside the 500-year floodplain. The SNF management facilities would be located and constructed to minimize any floodplain impact, as required by Executive Order 11988 (Floodplain Management) and DOE Orders. Site-specific surveys would be performed to more accurately determine precise locations of flooding elevations.

Operation of SNF management facilities would require approximately 9,863 gallons (37,335 liters) of water per day. This would mean that an additional 3.6 million gallons (13.6 million liters) of water would be used at the ORR per year. This figure is significantly less than the minimum monthly release for 1992 which was 3.5 billion cubic feet (100 million cubic meters) in May of that year (MMES 1993a). Therefore no impacts to water supply from SNF operations are expected.

Operation of SNF management facilities would involve the discharge of almost all water withdrawn, as very little would be consumed. A new onsite sanitary wastewater treatment plant would be required at the SNF facility. If all water withdrawn were to be treated and released at a constant rate over the course of a year, the increased flow from SNF operations would be approximately 0.13 gallon (0.5 liter) per second. Flow in Grassy Creek at its confluence with the Clinch River has been estimated at 20 gallons (80 liters) per second. Water discharge points and other appropriate mitigation measures would be selected in accordance with state and Federal requirements so as not to impact surface water quantity and flow in streams receiving discharges.

5.8.2 Surface Water Quality

During construction of SNF management facilities, 90 acres (36 hectares) would be disturbed, all in previously undisturbed areas. This would create the potential for increased sediment runoff into wetlands, adjacent to the site and along the downstream reaches of Grassy Creek as well as into Grassy Creek and its tributaries, which drain to the Clinch River. However, sediment runoff from construction activities would be controlled and minimized by implementing soil erosion control measures.

Under the Centralization Alternative, SNF management facilities would require a sanitary sewer system comprising a sewage treatment facility equipped with a sewage treatment and ejection pump system with a programmable controller and software. A pressurized sanitary sewer line would be provided that would run to a permitted stream discharge point (Johnson, V. 1994). This would accommodate the estimated 9,863 gallons (37,335 liters) per day of sanitary wastewater generated by SNF facilities and personnel, and would result in no appreciable impact to surface water quality. This system would be operated in accordance with State of Tennessee permitting requirements.

The proposed SNF management facilities are designed to have no liquid release of wastewater with hazardous chemical or radiological characteristics related to SNF management operations. These facilities would be constructed using state-of-the-art technologies, including secondary containment, and leak detection and water balance monitoring equipment. Therefore

no environmental consequences related to surface water resources are anticipated from the normal operation of SNF management facilities.

A very low probability release scenario was evaluated to identify the potential environmental consequences of a liquid release to the environment under normal operating conditions. The release scenario was evaluated for information purposes only, as no normal operating releases are planned for the proposed facilities. The scenario evaluated consisted of a maximum potential liquid release to the environment under normal operating conditions such as an undetected secondary containment failure or piping leak. The scenario was developed using conservative estimates of the sensitivity of actual leak detection systems and operational source term data from similarly functioning facilities at the Idaho National Engineering Laboratory (INEL). The estimates for the hypothetical release included a point release of 5 gallons (19 liters) per day to the environment over the course of 1 month. The release volume and durations are considerably greater than existing leak detection system sensitivities, surveillance activities, and radiological surveys. Source terms were derived at the 95 percent confidence level from 8 years of operational data at the INEL Fluorinel and Storage Facility at the Idaho Chemical Processing Plant.

This release was assumed to occur at 40 feet (12 meters) below the land surface. This would be at either the depth of the vadose zone or the groundwater zone in most cases where SNF management facilities would be sited on the ORR. Any release to the vadose zone would migrate downward to the groundwater zone as described in Section 4.8.2. The upper layers of the groundwater zone in the ORR aquitards (where SNF management facilities would be sited) flow laterally to discharge points in nearby streams.

Most radiological constituents would be below drinking water standards at the point of release. Those radiological constituents above drinking water standards would be diluted in movements through the vadose zone, groundwater zone, and immediately upon entry into the receiving surface water body. Migration of contaminants through the vadose and groundwater zones would also be greatly reduced by sorption.

The short-term scenario evaluated would result in a long-term release of dilute contaminants to local streams and the Clinch River. Any release from the SNF management facilities would discharge to Grassy Creek through the subsurface. Although there are no continuous records of stream discharge for Grassy Creek, the average discharge of Grassy Creek to the Clinch River has been estimated at 20 gallons (80 liters) per second (Bailey and Lee 1991). The worst-case undetected release from the SNF facilities (5 gallons [19 liters] per day) would constitute less than 0.0003 percent of the estimated daily creek discharge to the Clinch River. Therefore, any hazardous constituents would be well below established standards at the confluence of Grassy Creek and the river. Even if a release were to occur during a period of low flow in Grassy Creek, the percentage would still be very small. Additionally, the 1992 minimum monthly release (in May) of 3.5 billion cubic feet (100 million cubic meters) at the Melton Hill Dam on the Clinch River averages to approximately 10,000 gallons (40,000 liters) per second (MMES 1994a). Therefore, no significant contaminant concentrations would be expected at the confluence of Grassy Creek and the Clinch River, or in the river itself.

5.8.3 Groundwater Quantity

No groundwater would be used for SNF management activities given the plentiful surface water supplies at the ORR. Therefore no impacts to groundwater quantity are expected.

5.8.4 Groundwater Quality

As previously mentioned in Section 5.8.2, the proposed SNF management facilities would be designed to have no liquid release to the environment of wastewater with hazardous chemical or radiological characteristics. However, for the purpose of this analysis, a conservative release scenario was analyzed.

As discussed in Section 4.8, virtually all mobile groundwater in the ORR aquitards is discharged to local streams through the upper layers of the groundwater zone. The deeper intervals of groundwater have extremely high residence times. Therefore, even the conservative scenario of a release to groundwater would have negligible impacts to these resources, and no significant impacts to offsite groundwater.

5.9 Ecological Resources

The Centralization and Regionalization Alternatives could affect ecological resources primarily through the alteration or loss of habitat. Potential impacts to terrestrial and aquatic resources and threatened and endangered species are described below for both alternatives.

Radiation doses received by terrestrial biota from SNF activities would be expected to be similar to those received by man. Although guidelines have not been established for acceptance limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for other species (NRC 1979). Evidence indicates that no other living organisms have been identified that are likely to be significantly more radiosensitive than man (Casarett 1968; National Academy of Sciences 1972). Thus, so long as exposure limits protective of man are not exceeded, no significant radiological impact on populations of biota would be expected as a result of SNF activities at the West Bear Creek Site.

5.9.1 Centralization Alternative

Under this alternative, construction of the proposed SNF management facility would result in the disturbance of approximately 90 acres (0.36 square kilometers), or less than 1 percent of the ORR. It is assumed that the area to be disturbed includes construction laydown areas, grading, and new buildings, and that the access road or other rights-of-ways have not been included in total area to be disturbed. Vegetation within the area proposed for the SNF management facility would be destroyed during land clearing activities but may be mitigated by revegetating with native species where possible. Vegetation cover in this area is predominantly oak-hickory forest or pine and pine-hardwood forest. Both forest types are common on the ORR and within the region.

Construction of the proposed SNF management facility would have some adverse effects on animal populations. Less mobile animals, such as amphibians, reptiles, and small mammals, within the project area would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to nearby suitable habitat. The long-term survival of these animals would depend on whether the area to which they moved was at or below its carrying capacity. Areas that would be revegetated upon completion of construction would be of minimal value to most wildlife but may be repopulated by more tolerant species.

The Migratory Bird Treaty Act is primarily concerned with the destruction of migratory birds, as well as their eggs and nests. It may be necessary to survey construction sites for the nests of migratory birds prior to construction and/or avoid clearing operations during the breeding season.

Activities associated with operation, such as noise, increased human presence and traffic, and night lighting could affect wildlife living immediately adjacent to the site. While these disturbances may cause some sensitive species to move from the area, most animals should be able to adjust.

Construction of the proposed SNF management facility would likely displace the forested wetlands adjacent to tributaries of Grassy Creek flowing through the proposed site. This unavoidable displacement of wetlands would be accomplished in accordance with the U.S. Army Corps of Engineers and Tennessee Water Quality Control Administration requirements. The potential also exists to disturb wetlands further down stream through erosion and sedimentation. Such impacts would be controlled through implementation of a soil erosion and sediment control plan. Construction-related discharges to Grassy Creek would be relatively low and have negligible impacts to wetlands associated with the creek. No impacts to wetlands are anticipated during facility operations.

Construction of the proposed SNF management facility would require the rechanneling of tributaries to Grassy Creek that cross the proposed site and, thus, the loss of this aquatic habitat. In addition, soil erosion due to construction could cause water quality changes (primarily sediment loading) to Grassy Creek and its tributaries. These impacts could be minimized by implementation of soil erosion and sediment control measures. No operational impacts to aquatic resources are anticipated. It is assumed that the proposed project will have a water retention pond and a sewage lagoon area within the security fence that may provide minimal habitat for amphibians in the area.

No federally listed species are expected to be affected by construction and operation of the SNF management facility. Site surveys will be required to verify the presence of state-listed or other special status species. Land clearing activities may destroy protected plant species, such as purple fringeless orchid and pink lady's-slippers, that may occur within the site. State-listed species including the Cooper's, sharp-shinned, and red-shouldered hawks, the barn owl, and the black vulture, which potentially occur in the area, could be impacted by project activities. Approximately 90 acres (36 hectares) of potential nesting and foraging habitat would be lost as a result of construction activities. Because this type of habitat is abundant in the area, the loss is not expected to affect the viability of populations of these species. However, appropriate steps would be taken to prevent nest disturbance. The DOE would consult with the Tennessee Department of Environment and Conservation as appropriate to avoid or mitigate imminent impacts to state-listed species.

5.9.2 Regionalization Alternative

Impacts under this alternative are expected to be generally the same as under the Centralization Alternative. The major difference between the two is the total area to be disturbed. The Regionalization Alternative is expected to have fewer buildings required and, therefore, fewer acres to be disturbed.

5.10 Noise

As discussed in Section 4.10, noises generated on the ORR do not propagate offsite at levels that impact the general population. Thus, ORR noise impacts for both the Centralization and Regionalization Alternatives are those resulting from the transportation of personnel and materials to and from the site that affect the nearby communities, and those resulting from onsite sources that may affect some wildlife near these sources. The effect of noise on wildlife near SNF management facilities under the Centralization or Regionalization Alternatives would be addressed in a project-specific environmental assessments.

The transportation noises are a function of the size of the work force (e.g., an increase in the size of the work force would result in increased employee traffic and corresponding increases in deliveries by truck and rail, and a decreased work force would result in decreased employee traffic and corresponding decreases in deliveries). This analysis of traffic noise took into account noise from the major roadways that provide access to the ORR. Vehicles used to transport employees and personnel on roadways would be the principal sources of community noise impacts near the ORR from the Centralization and Regionalization Alternatives.

This analysis used the day-night average sound level to assess community noise as suggested by the U.S. Environmental Protection Agency (EPA 1974, 1982) and the Federal Interagency Committee on Noise (FICON 1992). The change in day-night average sound level from the baseline noise level for each alternative was estimated based on the projected change in employment and traffic levels from the baseline levels. The baseline levels are those for 1995. The combination of construction and operation employment was considered. A change in noise level below 3 decibels would not be expected to result in a change in community reaction (FICON 1992).

Under the Centralization Alternative the projected ORR work force might increase by about 9 percent in the years 2000 to 2002, during the peak construction period, and might decrease thereafter (Section 5.3). There would be a corresponding increase in private vehicle and truck trips to the site. The day-night average sound level at 15 meters (50 feet) from the roads that provide access to the ORR would be expected to increase by less than 1 decibel. No change is expected in the community reaction to noise along these routes. No mitigation efforts are necessary.

Under the Regionalization Alternative the traffic noise impacts would be the same as for the Centralization Alternative.

5.11 Traffic and Transportation

5.11.1 Centralization Alternative

The proposed SNF management activities would involve a small increase in the number of employees commuting to the ORR and the transportation of SNF and hazardous chemicals onsite. This section summarizes the potential transportation impacts due to the proposed SNF facilities on the ORR.

5.11.1.1 Level of Service. Levels of service were calculated for construction and operation of the SNF facility at the ORR. The maximum reasonably foreseeable scenario for operations occurs when the projected combined employees and population are at the highest level. This occurs in 2001, when there are 4,184 employees and a projected population in the Region of Influence of 528,800. The Region of Influence includes Anderson, Blount, Knox, Loudon, and Roane counties. This is the region from which employees can be expected to commute. The employees and population associated with the proposed action generate direct trips in the Region of Influence. These trips to the site are distributed to the Region of Influence road network according to percentages based on a traffic flow to the site from where employees historically have lived. Increase in baseline population and indirect site-related employees will generate indirect traffic trips in the Region of Influence. These trips are distributed based on the current average daily traffic per present population in the region of influence for a given segment. Direct and indirect average daily traffic is added and a new level of service is determined. Construction and operation employees contribute little to the future traffic because they represent such a small percentage of the Region of Influence population growth.

The following segment has a poorer level of service due to site-related impacts over the future baseline. Tennessee State Route 61 between Interstate 75 at Norris and 25W at Clinton will worsen to a level of service of E while Tennessee State Route 62 between Interstate 75 at Knoxville and US 441/TN 33 at Knoxville will worsen to a level of service of F. There are no other site-related impacts on any other segment.

Road reconstruction, widening, modification of interchanges, and new interchange construction projects are planned for segments of Bear Creek Valley Road, Scarboro Road, and Tennessee State Routes 58, 62, and 95 (Johnson, C. 1994; MMES 1991b).

Possible mitigation of impacts on local and regional roads having level of service of F could include adding lanes or employing traffic demand management.

The generic facility design would require rail access for Naval fuel delivery. This would create impacts that would be evaluated in detail if the site were selected for the SNF facility.

5.11.1.2 Transportation of Hazardous Chemicals. The hazardous chemicals required and hazardous waste generated by the proposed SNF facility operation are assumed to be transported by truck. The onsite transportation impacts for these hazardous chemicals and wastes shipments are calculated based on the assumptions that (a) they do not have any incident free impacts, (b) the material would not leak during transport, (c) only risk is due to traffic fatalities, and (d) the material spill of entire contents is bound by the risk evaluated for the Expended Core Facility considered under facility accidents.

The total distance for onsite shipment of these hazardous chemicals is assumed to be the maximum site boundary distance from the proposed SNF facility to the nearest highway. Based on the unit risk factor (Cashwell et al. 1986) and occupational and nonoccupational fatalities considering a rural setting, the onsite transportation risks are calculated, assuming 10 annual shipments.

The maximum one-way distance from the site to the ORR gate by which trucks would deliver hazardous waste is 16 kilometers (10 miles). Based on 1.5×10^{-8} accident occupational fatalities per kilometer per shipment, 1.92×10^{-4} accident occupational fatalities are estimated over a 40-year period. Based on 5.3×10^{-8} accident non-occupational fatalities per kilometer per shipment, 6.8×10^{-4} accident non-occupational fatalities are estimated for a 40-year period.

5.11.1.3 Transportation of Radioactive SNF. The definition of offsite transportation includes transportation of radioactive material from the shipping facility to the storage facility at the receiving site; therefore this local transportation does not separately address the onsite transportation impacts due to radioactive materials shipment except for handling at the storage

facility. Based on current inventories and expected future generation, DOE estimates approximately 480 spent nuclear shipments over 40 years (1995-2035) from the High Flux Isotope Reactor. The distance between the High Flux Isotope Reactor and the proposed SNF management facility at ORR is about 6 miles (9.75 km). Incident-free onsite radiological transportation impacts from the estimated 480 shipments were calculated for transportation crew members (occupational) and general population. Occupational dose of 0.34 person-rem over 40 years was calculated based on a unit risk factor of 7.16×10^{-5} person-rem per kilometer (Appendix I). This dose results in 1.36×10^{-4} fatal cancers. The general population dose of 8.56×10^{-3} person-rem over 40 years was calculated based on a unit risk factor of 1.83×10^{-6} person-rem per kilometer (Appendix I). This dose results in 4.28×10^{-6} fatal cancers.

5.11.2 Regionalization Alternative

The impacts due to the Regionalization Alternative would be less than those described for the Centralization Alternative.

5.12 Occupational and Public Health and Safety

5.12.1 Centralization Alternative

This section evaluates the impacts to human health resulting from both contaminated emissions and direct exposures associated with the proposed SNF management facility under the Centralization Alternative. Based on current inventories and expected future generation, DOE estimates approximately 480 spent nuclear shipments over 40 years (1995 - 2035) from the High Flux Isotope Reactor. The distance between the High Flux Isotope Reactor and the proposed SNF management facility at ORR is about 6 miles (9.75 km). Incident-free onsite radiological transportation impacts from the estimated 480 shipments were calculated for transportation crew members (occupational) and general population. Occupational dose of 0.34 person-rem over 40 years was calculated based on a unit risk factor of 7.16×10^{-5} person-rem per kilometer (Appendix I). This dose results in 1.36×10^{-4} fatal cancers. The general population dose of 8.56×10^{-3} person-rem over 40 years was calculated based on a unit risk factor of 1.83×10^{-6} person-rem per kilometer (Appendix I). This dose results in 4.28×10^{-6} fatal cancers.

5.12.1.1 Radiological Dose and Cancer Impacts. Computation and modeling (see Table 5.7-1) have shown that the dose rate (due to atmospheric effluents only) to the maximally exposed individual, conservatively taken to be at the site boundary of the ORR (without the presence of the interim storage facility), is 3.3 millirem per year of site operation with an associated risk of fatal cancer of 1.7×10^{-6} to this maximally exposed individual. It has also been established (see Section 4.12.4) that liquid effluents may present an additional plausible dose rate of 15.2 millirem per year of site operation (MMES 1993a) to a potential maximally exposed individual at the site boundary (due to both water consumption [0.2 millirem] and exposure from liquid material [15 millirem]), yielding a corresponding risk of 7.6×10^{-6} per year of operation. Subsequently, an additional 6.2 millirem per year to the postulated maximally exposed individual at the site boundary has been tabulated due to the presence of interim storage facility gaseous effluents (no radioactive liquid effluents are expected from the interim storage facility). Thus, if the spent fuel were brought to the ORR, it could result in a total cumulative dose rate (ORR + interim storage facility) to the maximally exposed individual at the site boundary of 24.7 millirem per year of site operation (see Table 5.12-1), with an associated total risk from ORR operations of 1.2×10^{-5} for fatal cancer; the resulting increase in risk to this individual from ORR operations with SNF management included is 34 percent. The total dose (24.7 millirem) to the maximally exposed individual is well within all applicable DOE limits (i.e., 4 millirem per year from the drinking water pathway, 10 millirem per year from the airborne release pathways, and 100 millirem per year total for all pathways). Table 5.12-1 shows the relationship among the various sources of radiation doses to the maximally exposed individual. The risks are presented there for both 1 and 40 years of exposure. The latter values are approximate and correspond to the operating lifetime of the SNF facility.

The annual population dose (80-kilometer [50-mile] radius) from total site operations (without the interim storage facility) is 54 person-rem, resulting in an increase of fatal cancer of 0.027. The increase in annual population dose from SNF operations is 5 person-rem, resulting in an increase of 2.5×10^{-3} for fatal cancer.

Over 40 years the increase in fatal cancers from SNF operations is 0.10. The increase of 9 percent in fatal cancers to the population from site operations with SNF results in an increase from 0.019 to 0.021 percent in the comparison of the dose received from ORR to that received from background. Table 5.12-1 also includes a summary of these population health impacts.

Table 5.12-1. Critical Interim Storage Facility impacts on radiation dose and cancer risks at ORR.

	Dose rate to the maximally exposed individual (mrem per yr)	Associated fatal cancer risk (yr of operation)[a]	Associated facility lifetime fatal cancer risk (40 years)[a]	Population dose from total site operations (person-rem per yr)	Associated total cancer increase (person per yr of operation)	Associated facility lifetime fatal cancer increase (person per 40 years)
Natural background	295	1.5×10^{-4}	5.9×10^{-3}	279,000	140	5,580
Public						
Baseline site operations	18.5	9.2×10^{-6}	3.7×10^{-4}	54	0.027	1.1
SNF operations	6.2	3.1×10^{-6}	1.2×10^{-4}	5.2	2.5×10^{-3}	0.10
Baseline & SNF	24.7	1.2×10^{-5}	4.9×10^{-4}	59	0.030	1.2
Percent increase SNF over baseline	34	34	34	9	9	9
Workers						
Baseline site operations	2.8[b]	1.1×10^{-6}	4.5×10^{-5}	48	0.019	0.76
SNF operations	40[b]	1.6×10^{-5}	6.4×10^{-4}	32	0.013	0.40[a]

a. Facility lifetime fatal cancer risk accounts for time-varying number of workers.
b. Dose rate to an average worker.

It has been assumed that the additional doses to SNF workers (due to interim storage facility operations) will be similar in nature to those for major DOE facility Waste Processing/Management personnel. Hence, by examining the dose data from 1989, 1990, and 1991 for Richland, INEL, and Savannah River Site and assuming that the nuclear activity of the SNF would remain fairly constant until it is dealt with at the interim storage facility, it may be asserted that a maximally exposed interim storage facility worker could plausibly receive an additional (above background) annual dose of 3 rem from normal operations; this is equivalent to a risk of 1.2×10^{-3} for fatal cancer per year of operation. However, the average calculated dose (incurred in 1989, 1990, and 1991) to SNF workers was approximately 40 millirem per year; this is equivalent to a risk of 1.6×10^{-5} for fatal cancer per year of operation, and to an approximate risk of 6.4×10^{-4} to a worker who is present during the entire 40-year facility lifetime.

An excess of 0.013 fatal cancer among all SNF facility workers is projected from peak annual operations; exposures to radiation over the lifetime of SNF operations could result in an excess of 0.40 fatal cancer. The maximum health effects due to radiological doses to a noninvolved worker, i.e., an ORR worker at a faciity other than SNF, would be on the order of 1 percent of the occupational exposure to an SNF worker based on analyses for the SRS and INEL sites. Table 5.12-1 includes a summary of the doses and fatal cancer risks to SNF workers.

5.12.1.2 Chemical Exposure Health Impacts. The calculated atmospheric maximum concentrations of hazardous chemicals (at the site boundary) for the proposed action are presented in Table 5.7-5 in Section 5.7. The maximum concentrations at the site boundary reflect an exposure to a maximally exposed individual, whereas the maximum onsite concentrations reflect an exposure to a worker. Of the potential hazardous chemicals identified for the proposed action, cadmium, nickel and chromium VI (chrome) are carcinogens for which a total cancer risk is calculated. The remaining seven chemicals are noncarcinogens for which a hazard index is calculated. A hazard index value of greater than 1 serves as an indicator for potential adverse health effects.

The offsite concentrations in Table 5.7-5 represent values at public access roads within the reservation. However, a maximally exposed individual is assumed to be unable to take up residence on these roads, but instead takes up residence along the reservation fence line. The concentrations at the fence line are 62 percent of those listed as offsite. On the other hand, the

concentrations at the roads, being the highest listed within the fence line, are used here to represent maximum concentrations for ORR workers.

Based on the maximum hazardous chemical concentrations at the site boundary, the lifetime fatal cancer risk and hazard index to the maximally exposed member of the public are 2.5×10^{-12} and 1.2×10^{-2}, respectively. Based on the maximum concentrations onsite, the lifetime fatal cancer risk and hazard index to a worker are 4.0×10^{-12} and 1.9×10^{-2}, respectively. This indicates that there will be virtually no health impacts from nonradiological releases.

5.12.1.3 Labor and Construction Health Risks. There are expected to be 25,212 total occupational/total labor worker-years for the 40-year duration of the interim storage facility. Hence, over the 40-year interim storage facility life span, it is estimated that 807 total injuries/illnesses and 0.81 fatality to DOE and contractor personnel would result. The expected 4,352 total construction worker-years for the 40-year duration of the interim storage facility results in 270 total injuries/illnesses and 0.48 fatality to DOE and contractor personnel.

5.12.2 Regionalization Alternative

Although the Regionalization Alternative is not explicitly analyzed, its impacts will be less than those from the Centralization Alternative.

5.13 Utilities and Energy

Direct changes in utility demand as a result of the Centralization and Regionalization Alternatives were compared against the current capacity and peak demand for each utility resource. Impacts to provision of a utility are considered to occur if the current demand, average annual demand, or peak demand for a utility is equal to or exceeds the current available capacity within the designated Region of Influence. For the purpose of analysis, the Region of Influence for each resource area is defined as the area served by the utility provider responsible for meeting the service demands of the ORR.

5.13.1 Centralization Alternative

5.13.1.1 Water Consumption. For the Centralization Alternative, approximately 0.43 liter per second (6.85 gallons per minute) of water is required to operate all the modules within the facility (Harr 1994). The K-25 plant, which would provide water to the site, has a capacity of 184 liters per second (2,917 gallons per minute) (Fritts 1994).

The proposed SNF management facilities would require approximately 0.2 percent of the K-25 plant's water capacity. The K-25 plant would operate at 53 percent of its capacity when the SNF facilities' water requirements are combined with the 1990 peak water usage of 97 liters per second (1,533 gallons per minute).

5.13.1.2 Electrical Consumption. The proposed SNF management facilities under the Centralization Alternative would require approximately 23,000 megawatt hours of electricity per year or approximately 2.63 megavolt-amperes average demand (Harr 1994). This represents 0.3 percent of ORR's 920 megavolt-ampere connected capacity. Thirty-one percent of the connected capacity of ORR would be utilized when the peak electric requirement of 285 megavolt-amperes was combined with the electrical requirements of the Centralization Alternative.

5.13.1.3 Fuel Consumption. Energy requirements for the proposed SNF management facilities under the Centralization Alternative were calculated assuming that electrical power purchased from a utility provider was the primary source of energy; however, fossil fuels may be used to power backup generators and during construction. The amount of fuel required for these operations would be small and should not substantially increase ORR fuel requirements.

5.13.1.4 Wastewater Disposal. Under the Centralization Alternative, approximately 0.43 liter per second (6.85 gallons per minute) of wastewater would be generated (Harr 1994). A new onsite sanitary sewage system and wastewater treatment plant might be required at the SNF facility. If a new system is not built, and sanitary sewage and wastewater are treated at K-25, this addition would represent approximately 2 percent of the K-25 sanitary sewer treatment system capacity of 26 liters per second (417 gallons per minute). Ninety-four percent of the wastewater capacity of the K-25 sanitary sewer treatment system would be utilized when the peak wastewater

production of 24 liters per second (378 gallons per minute) was combined with the wastewater production of the SNF management facilities.

5.13.2 Regionalization Alternative

5.13.2.1 Water Consumption. The proposed SNF management facilities under the Regionalization Alternative would require less water than the facilities under the Centralization Alternative; therefore, the impacts would be less.

5.13.2.2 Electrical Consumption. The proposed SNF management facilities under the Regionalization Alternative would require less electricity than the facilities under the Centralization Alternative; therefore, the impacts would be less.

5.13.2.3 Fuel Consumption. Energy requirements for the proposed SNF management facilities under the Regionalization Alternative were calculated assuming that electrical power purchased from a utility provider was the primary source of energy; however, fossil fuels may be used to power backup generators and during construction activities. The amount of fuel required for these operations would be small and should not substantially increase ORR fuel requirements.

5.13.2.4 Wastewater Disposal. The proposed SNF management facilities under the Regionalization Alternative would produce less wastewater than the Centralization Alternative; therefore, the impacts would be less.

5.14 Materials and Waste Management

This section discusses the potential environmental consequences of the Centralization and Regionalization Alternatives for the management of chemical raw materials and transuranic, low-level radioactive, and hazardous waste at the ORR. Nonhazardous (sanitary) wastes are discussed in Section 5.8. Section 4.14 describes the waste categories and outlines the ongoing waste management activities for the ORR. These waste management activities include onsite and offsite waste treatment, onsite and offsite waste disposal, and onsite waste storage. Section 4.14 also describes the chemical raw material management activities for the ORR.

5.14.1 Methodology

This analysis considers the impact of the Centralization and Regionalization Alternatives on current waste management activities at the ORR (baseline conditions). In addition to requiring land area for SNF management, both alternatives would generate transuranic, low-level radioactive, hazardous, and nonhazardous wastes. Neither alternative is projected to generate mixed wastes or high-level wastes. This analysis is based on a comparison of the projected amounts of waste generated by the Centralization and Regionalization Alternatives versus the current waste generation rates and storage capacity at the ORR.

5.14.2 Materials and Waste Management

SNF management activities would require the use of chemicals, and it is conservatively assumed that all chemical raw materials used within the proposed SNF management facility would become hazardous wastes. The proposed SNF management facility would contribute transuranic, solid low-level, and sanitary (sewage) wastes. Table 5.14-1 presents the estimated waste generations by waste classification for each of the two alternatives (Centralization and Regionalization) and by each of two storage options (wet storage, dry storage).

5.14.2.1 Centralization Alternative. Under the Centralization Alternative, all DOE SNF (including Naval and domestic and foreign research reactors) will be transferred to and managed at the ORR.

5.14.2.2 Wet Storage Option. The wet storage option would generate transuranic, low-level, hazardous, and sanitary wastes. The effect that the projected amounts of each of these wastes would have on the ORR waste management is discussed below.

5.14.2.2.1 Transuranic Waste—Over a period of 40 years of operation the projected amount of transuranic waste generated due to the recovery and purification of transuranic products would be 644 cubic meters (22,750 cubic feet). The current storage capacity at the ORR (ORNL) is 833.4 cubic meters (295,000 cubic feet). ORNL will continue to generate transuranic waste, and disposal is eventually planned for the Waste Isolation Pilot Plant unit. If the Waste Isolation Pilot Plant unit does not come on line, the ORR transuranic waste storage

Table 5.14-1. Ten-year cumulative estimated waste generation for SNF alternatives at the ORR (m^3).[a]

Alternative/ storage option	Time period 1995-2004	2005-2014	2015-2024	2025-2034
Centralization Alternative				
Wet storage option				
Transuranic waste	161	161	161	161
Low-level waste	1,950	1,950	1,950	1,950
Hazardous waste	74	74	74	74
Sanitary waste (sewage)	1.2×10^5	1.2×10^5	1.2×10^5	1.2×10^5
Dry storage option				
Low-level waste	76	76	76	76
Sanitary waste (sewage)	1.9×10^4	1.9×10^4	1.9×10^4	1.9×10^4
Regionalization Alternative				
Wet storage option				
Transuranic waste	<161	<161	<161	<161
Low-level waste	<1,950	<1,950	<1,950	<1,950
Hazardous waste	<74	<74	<74	<74
Sanitary waste (sewage)	$<1.2 \times 10^5$	$<1.2 \times 10^5$	$<1.2 \times 10^5$	$<1.2 \times 10^5$
Dry storage option				
Low-level waste	<76	<76	<76	<76
Sanitary waste (sewage)	$<1.9 \times 10^4$	$<1.9 \times 10^4$	$<1.9 \times 10^4$	$<1.9 \times 10^4$

a. Source: Harr (1994).

capacity may have to be expanded to accommodate transuranic waste generated at the SNF facility.

5.14.2.2.2 Low-Level Waste—The wet storage option would generate liquid low-level waste as a result of its interim storage in water. Over a period of 40 years of operation, an estimated 7,800 cubic meters (over 2 million gallons) of low-level liquid waste might be generated. The total ORR (Y-12, K-25, ORNL) storage capacity for liquid low-level wastes is about 98,300 cubic meters (about 26 million gallons) (see Tables 4.14-1, 4.14-3, and 4.14-5). Impacts would be small.

5.14.2.2.3 Hazardous Wastes—Installation of the proposed SNF management facility would require additional management of hazardous wastes, including the placement of satellite storage areas within the SNF complex and more frequent offsite shipments of hazardous wastes. It is estimated that the wet storage option will generate approximately 7.4 cubic meters (261 cubic feet) of waste annually. Currently ORR manages about 10,000 cubic meters (about 353,000 cubic feet) of hazardous waste annually (see Tables 4.14-1, 4.14-3, and 4.14-5); therefore, the impact of SNF generated hazardous waste on the management of hazardous waste at the ORR would be minimal.

5.14.2.2.4 Sanitary Waste—Sanitary wastes are covered in Section 5.8.

5.14.2.3 Dry Storage Option. The dry storage option would generate low-level waste and sanitary waste. The effects that the projected amounts of each of these wastes would have on the ORR waste management is discussed below.

5.14.2.3.1 Low-Level Waste—The low-level radioactive contaminated waste stream would result from wastes generated during decontamination operations. Over a period of 40 years of operation, an estimated 304 cubic meters (10,700 cubic feet) of low-level waste might be generated. As reported in Section 5.14.2.2.2 the total ORR storage capacity for liquid low-level waste is about 98,300 cubic meters (about 26 million gallons). Impacts from SNF operations on low-level waste management would be minimal.

5.14.2.3.2 *Sanitary Waste*—Sanitary wastes are covered in Section 5.8.

5.14.2.2 *Regionalization Alternative.* Under the Regionalization Alternative, the ORR would be the alternate site for the SRS. This alternative would generate less waste from the SNF complex than the Centralization Alternative since it is the alternative that stores less SNF. For either the wet storage or dry storage option, the waste generated would be less than those presented for the Centralization Alternative. Therefore, Table 5.14-1 presents the estimated waste generation for the SNF for the Regionalization Alternative as less than those generated for the Centralization Alternative. The impacts presented for each of the waste categories for its two options (wet storage, dry storage) for the Centralization Alternative apply to the Regionalization Alternative as well.

5.15 Facility Accidents

A potential exists for accidents at facilities associated with the handling, inspection, and storage of spent nuclear fuel at the ORR. Accidents can be categorized into events that are abnormal (for example, minor spills), events a facility was designed to withstand, and events a facility is not designed to withstand. These categories are termed *abnormal, design basis*, and *beyond design basis* accidents, respectively. Summarized here are consequences of possible facility accidents for a member of the public at the nearest site boundary and at the nearest road, for the collective population within 80 kilometers (50 miles), for workers, and for the environment. See Section 5.11 for a summary of the assessment of transportation accidents.

A review of the historical record of accidents at the ORR is summarized in the following section. Methods used to assess potential future events are summarized in Section 5.15.2. Evaluations of accident impacts by alternative are summarized in Sections 5.15.3 through 5.15.7. A summary comparison of accident impacts by alternative is given in Section 3.2. Additional supporting documentation for the accident impacts is given in a separate report (HNUS 1995).

This section examines the various activities that have been performed to assess the potential for accidents and their consequences for workers and the public for each alternative. A set of potential reasonably foreseeable accidents over the 40-year period are described which envelop all accidents. Secondary impacts of accidents pertaining to cultural resources, economics, land use, endangered species, water resources, and ecology are also addressed. This section also

addresses emergency preparedness plans that have been established to mitigate the primary and secondary effects of accidents.

5.15.1 Historical SNF Accidents at ORR

The records of unusual events, including accidents, at the ORR have been reviewed to determine whether there have been any accidents with offsite impacts. The results indicate that there have been no accidents at the ORR associated with SNF that have had significant offsite consequences for the general public.

5.15.2 Methodology

5.15.2.1 Existing Facilities.

5.15.2.1.1 *Assumptions and Approach*—The potential accidents associated with the existing SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the No Action Alternative. Source terms were developed for each accident analysis. The GENII code (PNL 1988) was used to estimate accident consequences for the general public and for individuals onsite or at the site boundary based on both 50 percent and 95 percent meteorology. Accident consequences and risk are described in terms of dose, cancer fatalities, and total health detriments for workers, an individual at the site boundary, and the public residing as far as 80 kilometers (50 miles) from the proposed SNF management facility.

5.15.2.1.2 *Accident Screening*—The potential accidents associated with the existing SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the No Action Alternative. Initiating events were reviewed including natural phenomena (earthquakes, tornadoes, etc.), human initiated events (human error), equipment failures, fires, explosions, airplane crashes, and terrorism. One reference design basis fuel handling accident was selected for detailed analysis.

The dam in the High Flux Isotope Reactor fuel pool is removed and stored within the pool during refueling operations. The reference design basis fuel handling accident postulated that during refueling operations, the dam falls and damages all the 62 spent fuel cores, including the most recently discharged core, located in the pool. The fission products from all 62 spent fuel cores are released to the water in the pool (ORNL 1992b).

A beyond design basis tornado accident was considered that resulted in collapse of the High Flux Isotope Reactor bay roof and the roof's major structural member falls into the fuel pool and damages all the 62 spent fuel cores located in the pool. The fission products from all 62 spent fuel cores are released to the water in the pool (Flanagan 1994).

Additional beyond design basis accidents initiated by an airplane crash were postulated for the High Flux Isotope Reactor and Bulk Shielding Reactor but were screened out because the probability of an airplane crash into the fuel pool was estimated to be less than 1.0 x 10^{-7} per year.

The consequences of postulated operational and reference design basis accidents for the existing facilities are enveloped by the accident consequences presented in Subsection 5.15.4 for the Centralization Alternative.

5.15.2.2 New Facilities. In the absence of suitable design details for new SNF management facilities during this stage of the SNF Management Program upon which to base an accident analysis, the approach makes use of accident scenarios and associated data that have been analyzed and documented for similar facilities. They include spent nuclear fuel facilities at INEL, Hanford, Savannah River Site, and Naval sites.

5.15.2.2.1 Assumptions and Approach—A number of postulated accidents for the similar facilities have been selected to serve as a common basis for estimating accident consequences for workers and the public at the ORR site. Although the accident scenarios, source terms, and related assumptions are common for both sites, the estimated consequences are unique to the ORR site because of site differences in modeling parameters pertaining to distances to site boundaries and population centers, population distributions, and meteorology. The GENII code was used to estimate accident consequences for the general public and for individuals onsite or at the site boundary based on both 50 percent and 95 percent meteorology. Accident consequences and risk are described in terms of dose, cancer fatalities, and total health detriments for workers, an individual at the site boundary, a transient individual at the nearest public access, and the public residing as far as 80 kilometers (50 miles) from the proposed SNF

facility. The estimated frequency of each selected accident is based on the reference source documentation.

The probability of an airplane crash into the new SNF management facility is considered small because there are no nearby airports with large aircraft activity. The probability is expected to be in the 1 x 10^{-6} to 1 x 10^{-8} per year range. For calculational purposes the probability of this accident is conservatively estimated at 1 x 10^{-6} per year. Potential accidents initiated by an airplane crash into the SNF management facilities and the estimated consequences have been analyzed.

The secondary impacts of accidental releases of radioactive and hazardous materials are also addressed in a qualitative manner. Secondary impacts pertain to effects of accidents on land use, endangered species, water resources, cultural resources, and ecology.

5.15.2.2.2 Accident Screening—The potential accidents associated with existing SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the ORR. The source documentation for this purpose was primarily Appendices A, B, C, and D of Volume 1 of this EIS. The source documentation describes potential accidents for existing and planned SNF management facilities that were selected by a screening process. Initiating events were reviewed including natural phenomena (earthquakes, tornadoes, etc.), human initiated events (human error), equipment failures, fires, explosions, airplane crashes, and terrorism. Accidents associated with the Expended Core Facility operations at the ORR, were analyzed separately and the results are documented in Appendix D of this EIS. For the ORR the maximum reasonably foreseeable criticality and nonradiological accidents are associated with the Expended Core Facility. The potential for a criticality exists while the fuel is in dry storage, during handling, and in the wet storage pool. Although the probability of any criticality is very low, a hypothetical criticality of 1 x 10^{19} fissions was postulated in the Expended Core Facility wet pool as a basis for estimating the maximum reasonably foreseeable consequences of a criticality.

The selected accidents include beyond reference design basis events to reflect the magnitude of accident consequences that envelop all other accidents that have a reasonable probability of occurrence. They also include other accidents with lower consequences and typically higher probabilities of occurrence to show a range of accident types and consequences.

The accidents included in this set are reasonably foreseeable, meaning that there are one or more sequences of events that will lead to their occurrence and the sequence with the lowest probability of occurrence is greater than 1 x 10^{-7} per year. Accidents falling outside of this envelope, such as a meteorite impact, have been judged unreasonable because the probability of occurrence in less than 1 x 10^{-7} per year.

5.15.2.2.3 Accident Prevention and Mitigation — Under the Centralization and Regionalization alternatives, the SNF management facilities at the ORR will be of new design and construction and incorporate the latest technology for safety. The accidents postulated for the SNF management facilities are based on operations and safety analyses that have been performed at similar facilities. One of the major design goals for the SNF management facilities is to achieve a reduced risk to facility personnel and to public health and safety relative to that associated with similar functions at the existing SNF management facilities. Significant changes exist between design criteria and safety standards for the new SNF management facilities and those for the current facilities, thus reducing total risk. These changes include design to current DOE structural and safety criteria and to planned throughput and storage capacity.

The new SNF management facilities would be designed to comply with current Federal, state, and local laws, DOE Orders, and industrial codes and standards. This would provide facilities that are highly resistant to the effects of severe natural phenomena, including earthquake, flood, tornado, high wind, as well as credible events as appropriate to the site, such as fire and explosions, and man-made threats to its continuing structural integrity for containing materials.

Emergency preparedness plans have also been prepared for existing facilities and will be revised for new facilities to lower the potential consequences of an accident to workers and the public. All workers receive evacuation training to ensure timely and orderly personnel movement away from high-risk areas. Plans and arrangements with local authorities are also in place to evacuate the general public that may be at risk of exposure to hazardous materials that are accidentally released.

5.15.3 No Action Alternative

There is a potential for the accidental release of radioactive substances during various stages of SNF handling operations and storage. The operations begin with discharge of SNF from the reactor during refueling operations. The discharged SNF is placed in the fuel pool for cooling and short term storage. After an adequate cooldown period, SNF is removed from the pool and transported offsite for long term storage. Accidents that may occur during these handling operations and storage may involve the release of radioactive material to air or water pathways. The cause of accidents may be due to internal initiators, such as operator error, equipment failure, and terrorism, or external initiators, such as an earthquake.

In the event that SNF can not be transported offsite for long term storage, reactor operations will cease when the fuel pool is full. Presently the SNF stored in the ORR fuel pools is sound and has not deteriorated. If the existing SNF were to remain in the ORR fuel pools for an extended period of time and deterioration of the aluminum fuel cladding occurred, there are no existing facilities at the ORR to characterize the SNF.

5.15.3.1 Radiological Impacts. The potential accidents associated with the existing SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the No Action Alternative. One reference design basis accident and one beyond design basis accident were selected for detailed analysis. Although other accidents may occur, their estimated consequences are bounded by this beyond design basis accident or their probability of occurrence is less than 1.0 x 10^{-7}per year. If these accidents were to occur, the dose and risk to the onsite worker and the general population are shown in Tables 5.15-1 and 5.15-2 for 95 percent and 50 percent meteorology respectively. Similarly, cancer fatalities are shown in Tables 5.15-3 and 5.15-4, and the health effects are shown in Tables 5.15-5 and 5.15-6.

5.15.3.1.1 Reference Design Basis Accident—The dam that separates the High Flux Isotope Reactor pool from the clean center pool during normal reactor operation is moved to a position between the east and center clean pools prior to defueling the reactor. The dam is lifted approximately 3 feet above the water over its slot between the reactor and center pools, then moved with the crane across the center clean pool, and then lowered into its slot between the east and center pools. During this movement, and when the dam is being moved back, the fuel in the center pool is subjected to the possibility of dropping the dam and mechanically

Table 5.15-1. Summary of No Action Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b]	Worker[d] (rem)	Population (person-rem)	MEI (rem/yr)	NPAI	Worker (rem/yr)	Population (person-rem/yr)
Dropped dam	1.0×10^{-4} [e]	3.7×10^{-1} [c]	6.2×10^{-1}	2.3×10^{-2}	3.5×10^{3} [c]	3.7×10^{-5}	6.2×10^{-5}	2.3×10^{-6}	3.5×10^{-1}
Beyond design basis tornado	1.9×10^{-7}	4.9×10^{0} [d]	7.5×10^{1}	2.6×10^{1}	4.5×10^{4} [d]	9.3×10^{-7}	1.4×10^{-5}	4.9×10^{-6}	8.6×10^{-3}

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI) - Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

Table 5.15-2. Summary of No Action Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b]	Worker[d] (rem)	Population (person-rem)	MEI (rem/yr)	NPAI	Worker (rem/yr)	Population (person-rem/yr)
Dropped dam	1.0×10^{-4} [e]	8.6×10^{-2} [c]	1.9×10^{-1}	5.7×10^{-3}	1.2×10^{3} [c]	8.6×10^{-6}	1.9×10^{-5}	5.7×10^{-7}	1.2×10^{-1}
Beyond design basis tornado	1.9×10^{-7}	9.5×10^{-1} [d]	1.9×10^{1}	4.0×10^{0}	7.2×10^{3} [d]	1.8×10^{-7}	3.6×10^{-6}	7.6×10^{-7}	1.4×10^{-3}

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

Table 5.15-3. Summary of No Action Alternative accident analysis cancer fatality and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
Accident scenario	Frequency (per year)	MEI[a]	NPAI[b]	Worker[d]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0×10^{-4} [e]	1.8×10^{-4} [c]	3.1×10^{-4}	9.2×10^{-6}	1.7×10^{0} [c]	1.8×10^{-8}	3.1×10^{-8}	9.2×10^{-10}	1.7×10^{-4}
Beyond design basis tornado	1.9×10^{-7}	2.5×10^{-3} [d]	7.5×10^{-2}	2.0×10^{-2}	2.3×10^{1} [d]	4.8×10^{-10}	1.4×10^{-8}	3.8×10^{-9}	4.4×10^{-6}

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

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Table 5.15-4. Summary of No Action Alternative accident cancer fatality and risk estimates for the Oak Ridge Site at 50 percent meteorology.

Accident scenario	Frequency (per year)	50 percent meteorology: Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
		MEI[a]	NPAI[b]	Worker[d]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0×10^{-4} [e]	4.3×10^{-5} [c]	9.5×10^{-5}	2.3×10^{-6}	6.2×10^{-1} [c]	4.3×10^{-9}	9.5×10^{-9}	2.3×10^{-10}	6.2×10^{-5}
Beyond design basis tornado	1.9×10^{-7}	4.8×10^{-4} [d]	9.5×10^{-3}	1.6×10^{-3}	3.6×10^{0} [d]	9.1×10^{-11}	1.8×10^{-9}	3.0×10^{-10}	6.8×10^{-7}

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

Table 5.15-5. Summary of No Action Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 95 percent meteorology.

Accident scenario	Frequency (per year)	95 percent meteorology: Total health detriments[a] MEI[b]	NPAI[c]	Worker[e]	Population	Total health detriment risk (detriments/year) MEI	NPAI	Worker	Population
Dropped dam	1.0×10^{-4} [f]	2.7×10^{-4} [d]	4.6×10^{-4}	1.3×10^{-5}	2.5×10^{0} [d]	2.7×10^{-8}	4.6×10^{-8}	1.3×10^{-9}	2.5×10^{-4}
Beyond design basis tornado	1.9×10^{-7}	3.6×10^{-3} [e]	1.1×10^{-1}	2.9×10^{-2}	3.3×10^{1} [e]	6.8×10^{-10}	2.1×10^{-8}	5.5×10^{-9}	6.3×10^{-6}

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI).

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. Radiation exposure received from inhalation and external pathways.

f. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

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Table 5.15-6. Summary of No Action Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
		Total health detriments[a]				Total health detriment risk (detriments/year)			
Accident scenario	Frequency (per year)	MEI[b]	NPAI[c]	Worker[e]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0×10^{-4} [f]	6.3×10^{-5} [d]	1.4×10^{-4}	3.2×10^{-6}	9.0×10^{-1} [d]	6.3×10^{-9}	1.4×10^{-8}	3.2×10^{-10}	9.0×10^{-5}
Beyond design basis tornado	1.9×10^{-7}	6.9×10^{-4} [e]	1.4×10^{-2}	2.2×10^{-3}	5.3×10^{0} [e]	1.3×10^{-10}	2.7×10^{-9}	4.2×10^{-10}	1.0×10^{-6}

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI).

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. Radiation exposure received from inhalation and external pathways.

f. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

damaging the fuel. There is also a possibility that the dam could somehow be dropped as it is being lowered into (or raised from) its place between the clean pools and then fall in a way that would damage the fuel in either pool. The reference design basis fuel handling accident postulated that during refueling operations, the dam falls and damages all the 62 spent fuel cores, including the most recently discharged core, located in the pool. The fission products from all 62 spent fuel cores are assumed to be instantaneously released into the water in the pool. The analysis assumed that the pool area exhaust system was operational, it carried off all evaporated fission products, it filtered the stream, and it released the remaining fission products up the stack. The source term released up the stack is shown in Table 5.15-7. The frequency of occurrence for this accident is in the range of 1.0 x 10^{-4} to 1.0 x 10^{-6} per year (ORNL 1992b).

5.15.3.1.2 Beyond Design Basis Accident—The beyond design basis accident postulated that a beyond design basis tornado with wind speeds of approximately 300 mph struck the High Flux Isotope Reactor reactor bay. The reactor bay roof collapses and the major structural member in the roof falls into the fuel pool and damages all the 62 spent fuel cores, including the most recently discharged core, located in the pool. The fission products from all 62 spent fuel cores are assumed to be instantaneously released into the water in the pool. The analysis assumed that all evaporated fission products are released directly to the environment at ground level. The source term is similar to the reference design basis accident source term present in Table 5.15-7 except that no credit was taken for filtration of the iodine evaporated from the pool. The iodine released in the beyond design basis source term is 100 times greater than the iodine released in the reference design basis accident source term (Flanagan 1994).

The annual return frequency of a tornado with wind speeds of approximately 300 mph at ORR is 1.4 x 10^{-5}. The conditional probability for collapse of the reactor bay roof during a 300 mph tornado is 0.46. The ratio of the spent fuel area to the reactor bay floor area (i.e., the probability that the falling structural member will fall into the spent fuel area of the fuel pool) is 0.03. The frequency of occurrence for this beyond design basis accident is 1.9 x 10^{-7} per year (Flanagan 1994).

Due to the dose consequences associated with the postulated accident, protective actions were assumed for the offsite population. The analysis took no credit for evacuation of the public from the affected area. However, credit was taken for removing contaminated food from the general public.

Table 5.15-7. Estimated radionuclide releases for the High Flux Isotope Reactor fuel pool dam drop accident at ORR.

	Release Duration	
Isotope	0-2 hr Curies	0-30 day Curies
Hydrogen-3 (Tritium)	3.5 x 10^{2}	3.5 x 10^{2}
Krypton-83m	1.9 x 10^{2}	1.9 x 10^{2}
Krypton-85	1.0 x 10^{4}	1.0 x 10^{4}
Krypton-85m	3.6 x 10^{3}	3.6 x 10^{3}
Krypton-87	4.2 x 10^{-1}	4.2 x 10^{-1}
Krypton-88	1.1 x 10^{3}	1.1 x 10^{3}
Iodine-151	3.8 x 10^{0}	1.5 x 10^{1}
Iodine-132	5.0 x 10^{0}	5.1 x 10^{0}
Iodine-133	4.7 x 10^{0}	6.2 x 10^{0}
Iodine-134	2.2 x 10^{-7}	2.2 x 10^{-7}
Iodine-135	7.4 x 10^{-1}	8.1 x 10^{-1}
Xenon-131m	2.3 x 10^{3}	2.3 x 10^{3}
Xenon-133	8.7 x 10^{5}	8.7 x 10^{5}
Xenon-133m	2.5 x 10^{4}	2.5 x 10^{4}
Xenon-135	1.7 x 10^{5}	1.7 x 10^{5}
Xenon-135m	1.2 x 10^{3}	1.2 x 10^{3}

Source: ORNL 1992b

5.15.3.2 Nonradiological Hazards. The two bounding accidents involving nonradiological hazards postulated for the Centralization Alternative in subsection 5.15.4.2 are assumed to be bounding for the No Action Alternative. SNF operations under the No Action Alternative should not introduce any nonradiological hazards unique to the ORR SNF facilities.

5.15.4 Centralization Alternative

There is a potential for the accidental release of radioactive substances during various stages of SNF handling operations and storage. The operations at the new SNF management facilities begin with the receipt of an SNF shipment by truck or rail carrier, followed by the unloading of the shipping cask from the transport vehicle. If the SNF requires cooling, the cask is placed into an unloading pool where the SNF is withdrawn from the cask, moved to a temporary wet storage basin, and placed into a fuel rack. Some SNF that does not require cooling will be handled in a special cell where it will undergo canning and/or characterization. SNF that does not have to be cooled and does not require canning and/or characterization will be loaded into a dry storage canister within a transfer cask and transported to modular above-grade dry storage. Accidents that may occur during these handling operations and storage at the existing or new SNF management facilities may involve the release of radioactive material to air or water pathways. The cause of accidents may be due to internal initiators, such as operator error, terrorism, and equipment failure, or external initiators, such as an airplane crash into a facility.

5.15.4.1 Radiological Impacts. The accidents described below have been chosen to envelop the consequences of potential accidents for the proposed new SNF management facilities at the ORR. Although other accidents may occur, their estimated consequences are bounded by the accidents in the envelope or their probability of occurrence is less than 1×10^{-7} per year. If these accidents were to occur, the dose and risk would be as shown in Tables 5.15-8 and 5.15-9 for 95 percent and 50 percent meteorology respectively. These doses are in addition to the average natural background radiation exposure of 360 millirem per year. Similarly, cancer fatalities are shown in Tables 5.15-10 and 5.15-11, and the health effects are shown in Tables 5.15-12 and 5.15-13.

5.15.4.1.1 Fuel Assembly Breach—Physical damage and breach of a fuel assembly could accidentally occur from dropping, objects falling on the assembly, or cutting into the fuel

Table 5.15-8. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b] (rem)	Worker[c] (rem)	Population[d] (person-rem)	MEI (rem/year)	NPAI (rem/year)	Worker (rem/year)	Population (person-rem/year)
Fuel assembly breach	1.6×10^{-1} [e]	1.2×10^{-2}	3.8×10^{-3}	1.5×10^{-3}	2.1×10^{1}	1.9×10^{-3}	6.1×10^{-4}	2.4×10^{-4}	3.4×10^{0}
Dropped fuel cask	1.0×10^{-4} [f]	7.8×10^{0}	1.2×10^{1}	4.7×10^{0}	1.9×10^{4}	7.8×10^{-4}	1.2×10^{-3}	4.7×10^{-4}	1.9×10^{0}
Severe impact and fire	1.0×10^{-6} [g]	5.6×10^{1}	8.8×10^{0}	3.4×10^{0}	1.0×10^{5}	5.6×10^{-5}	8.8×10^{-6}	3.4×10^{-6}	1.0×10^{-1}
Wind-driven missile impact into dry storage	1.0×10^{-5}	2.2×10^{-2}	2.9×10^{-2}	1.2×10^{-2}	5.2×10^{1}	2.2×10^{-7}	2.9×10^{-7}	1.2×10^{-7}	5.2×10^{-4}
Airplane crash into dry storage	1.0×10^{-6} [g]	9.0×10^{0}	3.4×10^{1}	1.2×10^{1}	1.7×10^{4}	9.0×10^{-6}	3.4×10^{-5}	1.2×10^{-5}	1.7×10^{-2}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	7.6×10^{1}	5.8×10^{1}	2.3×10^{1}	1.2×10^{5}	7.6×10^{-5}	5.8×10^{-5}	2.3×10^{-5}	1.2×10^{-1}
Airplane crash into water pool	1.0×10^{-6} [g]	1.4×10^{-1}	5.9×10^{-2}	2.3×10^{-2}	5.6×10^{3}	1.4×10^{-7}	5.9×10^{-8}	2.3×10^{-8}	5.6×10^{-3}

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. Dose received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-9. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b] (rem)	Worker[c] (rem)	Population[d] (person-rem)	MEI (rem/year)	NPAI (rem/year)	Worker (rem/year)	Population (person-rem/year)
Fuel assembly breach	1.6×10^{-1} [e]	1.2×10^{-3}	6.7×10^{-4}	3.2×10^{-4}	2.5×10^{0}	1.9×10^{-4}	1.1×10^{-4}	5.1×10^{-5}	4.0×10^{-1}
Dropped fuel cask	1.0×10^{-4} [f]	7.5×10^{-1}	2.2×10^{0}	1.0×10^{0}	2.7×10^{3}	7.5×10^{-5}	2.2×10^{-4}	1.0×10^{-4}	2.7×10^{-1}
Severe impact and fire	1.0×10^{-6} [g]	5.5×10^{0}	1.6×10^{0}	7.5×10^{-1}	1.2×10^{4}	5.5×10^{-6}	1.6×10^{-6}	7.5×10^{-7}	1.2×10^{-2}
Wind-driven missile impact into dry storage	1.0×10^{-5}	2.1×10^{-3}	5.5×10^{-3}	2.5×10^{-3}	7.7×10^{0}	2.1×10^{-8}	5.5×10^{-8}	2.5×10^{-8}	7.7×10^{-5}
Airplane crash into dry storage	1.0×10^{-6} [g]	8.9×10^{-1}	6.2×10^{0}	2.7×10^{0}	2.5×10^{3}	8.9×10^{-7}	6.2×10^{-6}	2.7×10^{-6}	2.5×10^{-3}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	7.2×10^{0}	1.1×10^{1}	5.1×10^{0}	1.5×10^{4}	7.2×10^{-6}	1.1×10^{-5}	5.1×10^{-6}	1.5×10^{-2}
Airplane crash into water pool	1.0×10^{-6} [g]	1.3×10^{-2}	1.1×10^{-2}	5.0×10^{-3}	5.2×10^{2}	1.3×10^{-8}	1.1×10^{-8}	5.0×10^{-9}	5.2×10^{-4}

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. Dose received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-10. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Oak Ridge Site at 95 percent meteorology.

Accident scenario	Frequency (per year)	95 percent meteorology: Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
		MEI[a]	NPAI[b]	Worker[c]	Population[d]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [e]	6.0×10^{-6}	1.9×10^{-6}	6.0×10^{-7}	2.1×10^{-2}	9.6×10^{-7}	3.0×10^{-7}	9.6×10^{-8}	3.4×10^{-3}
Dropped fuel cask	1.0×10^{-4} [f]	3.9×10^{-3}	6.0×10^{-3}	1.9×10^{-3}	1.9×10^{1}	3.9×10^{-7}	6.0×10^{-7}	1.9×10^{-7}	1.9×10^{-3}
Severe impact and fire	1.0×10^{-6} [g]	5.6×10^{-2}	4.4×10^{-3}	1.4×10^{-3}	1.0×10^{2}	5.6×10^{-8}	4.4×10^{-9}	1.4×10^{-9}	1.0×10^{-4}
Wind-driven missile impact into dry storage	1.0×10^{-5}	1.1×10^{-5}	1.5×10^{-5}	4.9×10^{-6}	5.2×10^{-2}	1.1×10^{-10}	1.5×10^{-10}	4.9×10^{-11}	5.2×10^{-7}
Airplane crash into dry storage	1.0×10^{-6} [g]	4.5×10^{-3}	3.4×10^{-2}	4.8×10^{-3}	1.7×10^{1}	4.5×10^{-9}	3.4×10^{-8}	4.8×10^{-9}	1.7×10^{-5}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	7.6×10^{-2}	5.8×10^{-2}	1.8×10^{-2}	1.2×10^{2}	7.6×10^{-8}	5.8×10^{-8}	1.8×10^{-8}	1.2×10^{-4}
Airplane crash into water pool	1.0×10^{-6} [g]	6.9×10^{-5}	3.0×10^{-5}	9.2×10^{-6}	5.6×10^{0}	6.9×10^{-11}	3.0×10^{-11}	9.2×10^{-12}	5.6×10^{-6}

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

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Table 5.15-11. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
Accident scenario	Frequency (per year)	Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
		MEI[a]	NPAI[b]	Worker[c]	Population[d]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [e]	6.0×10^{-7}	3.4×10^{-7}	1.3×10^{-7}	1.3×10^{-3}	9.6×10^{-8}	5.4×10^{-8}	2.1×10^{-8}	2.1×10^{-4}
Dropped fuel cask	1.0×10^{-4} [f]	3.7×10^{-4}	1.1×10^{-3}	4.0×10^{-4}	2.7×10^{0}	3.7×10^{-8}	1.1×10^{-7}	4.0×10^{-8}	2.7×10^{-4}
Severe impact and fire	1.0×10^{-6} [g]	2.8×10^{-3}	8.1×10^{-4}	3.0×10^{-4}	1.2×10^{1}	2.8×10^{-9}	8.1×10^{-10}	3.0×10^{-10}	1.2×10^{-5}
Wind-driven missile impact into dry storage	1.0×10^{-5}	1.0×10^{-6}	2.7×10^{-6}	1.0×10^{-6}	3.8×10^{-3}	1.0×10^{-11}	2.7×10^{-11}	1.0×10^{-11}	3.8×10^{-8}
Airplane crash into dry storage	1.0×10^{-6} [g]	4.4×10^{-4}	3.1×10^{-3}	1.1×10^{-3}	2.5×10^{0}	4.4×10^{-10}	3.1×10^{-9}	1.1×10^{-9}	2.5×10^{-6}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	3.6×10^{-3}	5.5×10^{-3}	2.0×10^{-3}	1.5×10^{1}	3.6×10^{-9}	5.5×10^{-9}	2.0×10^{-9}	1.5×10^{-5}
Airplane crash into water pool	1.0×10^{-6} [g]	6.4×10^{-6}	5.5×10^{-6}	2.0×10^{-6}	5.5×10^{-1}	6.4×10^{-12}	5.5×10^{-12}	2.0×10^{-12}	5.5×10^{-7}

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-12. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Total health detriments[a]				Total health detriment risk (detriments/year)			
Accident Scenario	Frequency (per year)	MEI[b]	NPAI[c]	Worker[d]	Population[e]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [f]	8.8×10^{-6}	2.8×10^{-6}	8.4×10^{-7}	3.1×10^{-2}	1.4×10^{-6}	4.5×10^{-7}	1.3×10^{-7}	5.0×10^{-3}
Dropped fuel cask	1.0×10^{-4} [g]	5.7×10^{-3}	8.8×10^{-3}	2.6×10^{-3}	2.7×10^{1}	5.7×10^{-7}	8.8×10^{-7}	2.6×10^{-7}	2.7×10^{-3}
Severe impact and fire	1.0×10^{-6} [h]	8.2×10^{-2}	6.4×10^{-3}	1.9×10^{-3}	1.5×10^{2}	8.2×10^{-8}	6.4×10^{-9}	1.9×10^{-9}	1.5×10^{-4}
Wind-driven missile impact into dry storage	1.0×10^{-5}	1.6×10^{-5}	2.1×10^{-5}	6.8×10^{-6}	7.5×10^{-2}	1.6×10^{-10}	2.1×10^{-10}	6.8×10^{-11}	7.5×10^{-7}
Airplane crash into dry storage	1.0×10^{-6} [h]	6.6×10^{-3}	5.0×10^{-2}	6.7×10^{-3}	2.4×10^{1}	6.6×10^{-9}	5.0×10^{-8}	6.7×10^{-9}	2.4×10^{-5}
Airplane crash into dry cell facility	1.0×10^{-6} [h]	1.1×10^{-1}	8.5×10^{-2}	2.6×10^{-2}	1.8×10^{2}	1.1×10^{-7}	8.5×10^{-8}	2.6×10^{-8}	1.8×10^{-4}
Airplane crash into water pool	1.0×10^{-6} [h]	1.0×10^{-4}	4.3×10^{-5}	1.3×10^{-5}	8.2×10^{0}	1.0×10^{-10}	4.3×10^{-11}	1.3×10^{-11}	8.2×10^{-6}

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure received from inhalation, external, and ingestion pathways.

f. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

g. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

h. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-13. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
Accident scenario	Frequency (per year)	Total health detriments[a]				Total health detriment risk (detriments/year)			
		MEI[b]	NPAI[c]	Worker[d]	Population[e]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [f]	8.8×10^{-7}	4.9×10^{-7}	1.8×10^{-7}	1.8×10^{-3}	1.4×10^{-7}	7.8×10^{-8}	2.9×10^{-8}	2.9×10^{-4}
Dropped fuel cask	1.0×10^{-4} [g]	5.5×10^{-4}	1.6×10^{-3}	5.6×10^{-4}	4.0×10^{0}	5.5×10^{-8}	1.6×10^{-7}	5.6×10^{-8}	4.0×10^{-4}
Severe impact and fire	1.0×10^{-6} [h]	4.0×10^{-3}	1.2×10^{-3}	4.2×10^{-4}	1.8×10^{1}	4.0×10^{-9}	1.2×10^{-9}	4.2×10^{-10}	1.8×10^{-5}
Wind-driven missile impact into dry storage	1.0×10^{-5}	1.5×10^{-6}	4.0×10^{-6}	1.4×10^{-6}	5.6×10^{-3}	1.5×10^{-11}	4.0×10^{-11}	1.4×10^{-11}	5.6×10^{-8}
Airplane crash into dry storage	1.0×10^{-6} [h]	6.5×10^{-4}	4.5×10^{-3}	1.5×10^{-3}	3.6×10^{0}	6.5×10^{-10}	4.5×10^{-9}	1.5×10^{-9}	3.6×10^{-6}
Airplane crash into dry cell facility	1.0×10^{-6} [h]	5.2×10^{-3}	8.0×10^{-3}	2.9×10^{-3}	2.2×10^{1}	5.2×10^{-9}	8.0×10^{-9}	2.9×10^{-9}	2.2×10^{-5}
Airplane crash into water pool	1.0×10^{-6} [h]	9.3×10^{-6}	8.0×10^{-6}	2.8×10^{-6}	8.0×10^{-1}	9.3×10^{-12}	8.0×10^{-12}	2.8×10^{-12}	8.0×10^{-7}

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure recieved from inhalation, external, and ingestion pathways.

f. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

g. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

h. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

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part of an assembly. The fuel cutting accident that has been postulated to occur at Savannah River Site facilities is chosen as representative of the fuel assembly breach accident (E. I. du Pont de Nemours & Co. 1983). During normal operations at the Savannah River Site, the inert, non-uranium-containing extremities of some spent nuclear fuel elements are cutoff in the repackaging basin before the bundling of the elements. The accident occurs when the actual uranium fuel is inadvertently cut, causing a radioactive release. The source term for this accident is shown in Table 5.15-14. The estimated frequency of occurrence for this accident is 1.6×10^{-1} per year based on the Savannah River Site's operating experience with SNF. However, because of anticipated differences in operations and facilities at the ORR, the actual frequency is expected to be much less than 1.6×10^{-1} per year.

5.15.4.1.2 Dropped Fuel Cask—The dropped fuel cask accident that has been postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the dropped fuel cask/fuel handling accident for the new Centralization Alternative facility at the ORR. This accident is initiated when a fuel cask is dropped and overturned in the fuel transfer area and broken fuel elements spill out of the cask, within the pool building but away from the pool. It is assumed that the shipping cask ruptures, exposing all of the broken fuel elements in three canisters--42 fuel elements, each containing 22.5 kilograms (50 pounds) of fuel. The source term for this accident is shown in Table 5.15-15. The probability of this accident is estimated to be less than 1×10^{-4} per year.

5.15.4.1.3 Severe Impact and Fire—The severe impact and fire accident that has been postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the severe impact and fire/onsite transportation accident for the new Centralization Alternative facility at the ORR. This accident assumes an unspecified initiating event that subjects the fuel assemblies to a severe impact, breach of the transport cask, and a fire. During the accident, the fuel pins rupture on impact or upon heating in the fire, which burns for an hour before being extinguished. Volatiles, particulates, and noble gases are released to the atmosphere. The source term for a release of 540 curies is shown in Table 5.15-16. The estimated probability of occurrence for this accident, reflecting the fact that the facilities at this site would be new, is less than 1×10^{-6} per year.

5.15.4.1.4 Wind-driven Missile Impact into Storage Casks—The wind-driven missile impact into storage casks accident that has been postulated to occur at the Naval Site

Table 5.15-14. Estimated radionuclide releases for a fuel assembly breach accident at ORR.[a]

Radionuclide	Release (Ci)
Iodine-131	7.1×10^{-2}
Iodine-133	1.4×10^{-30}
Krypton-85	1.8×10^{2}
Xenon-133m	1.1×10^{-8}
Xenon-133	1.1×10^{0}

a. Source: E.I. du Pont de Nemours & Co. (1983).

Table 5.15-15. Estimated radionuclide releases for a dropped fuel cask accident at ORR.[a]

	Release (Ci)	
Radionuclide	Onsite (2 hours)	Offsite (8 hours)
Plutonium-236	1.3×10^{-8}	5.4×10^{-8}
Plutonium-238	2.9×10^{-3}	1.2×10^{-2}
Plutonium-239	6.7×10^{-3}	2.7×10^{-2}
Plutonium-240	3.5×10^{-3}	1.4×10^{-2}
Plutonium-241	2.7×10^{-1}	1.1×10^{0}
Plutonium-242	1.3×10^{-6}	5.1×10^{-6}
Americium-241	5.7×10^{-3}	2.3×10^{-2}
Curium-244	2.8×10^{-4}	1.1×10^{-3}
Europium-154	5.4×10^{-3}	2.1×10^{-2}
Cesium-134	7.9×10^{-3}	3.2×10^{-2}
Cesium-137	4.5×10^{-1}	1.8×10^{0}
Cerium-144	1.7×10^{-3}	6.8×10^{-3}
Praseodymium-144	1.7×10^{-3}	6.8×10^{-3}
Praseodymium-144M	2.0×10^{-5}	8.1×10^{-5}
Promethium-147	1.2×10^{-1}	4.9×10^{-1}
Antimony-125	7.3×10^{-3}	2.9×10^{-2}
Tellurium-125M	1.8×10^{-3}	7.3×10^{-3}
Ruthenium-106	3.2×10^{-3}	1.3×10^{-2}
Strontium-90	3.5×10^{-1}	1.4×10^{0}
Yttrium-90	3.5×10^{-1}	1.4×10^{0}

a. Source: Appendix A, Table A-1.

Table 5.15-16. Estimated radionuclide releases for a severe impact and fire accident at ORR.[a]

Radionuclide	Release (Ci)
Hydrogen-3 (Tritium)	4.6×10^{1}
Krypton-85	4.0×10^{2}
Strontium-90	2.7×10^{-2}
Ruthenium-106	1.3×10^{0}
Cesium-134	1.7×10^{1}
Cesium-137	8.0×10^{1}
Plutonium-238	8.9×10^{-4}
Plutonium-239	1.6×10^{-3}
Plutonium-240	1.8×10^{-3}
Plutonium-241	7.3×10^{-2}
Americium-241	1.0×10^{-3}

a. Source: Appendix A, Table A-14.

(reference Volume 1, Appendix D) is chosen as representative of the wind-driven missile accident for the new Centralization Alternative facility at the ORR. This accident is initiated by natural phenomena: a major wind storm or tornado in excess of the facility design basis. In this scenario, a large object is propelled by the wind into a storage container, causing the container seal to be breached. No fuel damage would result from the impact because of the strength of the containers used. The source term is based on the spent nuclear fuel corrosion film. One percent of the original corrosion film on the fuel would be released from the cask into the atmosphere. The source term is shown in Table 5.15-17. The probability of this event is estimated to be less than 1×10^{-5} per year based on a design basis tornado probability of 1×10^{-3} per year and a missile impact with damage probability of less than 1×10^{-2}.

5.15.4.1.5 Airplane Crash Into Dry Storage—The airplane crash into dry storage accident that has been postulated to occur at the Naval Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the dry storage area accident for the new Centralization Alternative facility at the ORR. This accident is externally initiated by an airplane crash into the SNF dry storage facility. The accident is postulated to cause damage to a single storage cask. Due to the severity of the impact, the cask seal is assumed to be breached, resulting in damage to the fuel and the release of corrosion products, located on the SNF exteriors, to the environment. The impact also causes a fire and a release of fission products. It is assumed that 1 percent of all of the fuel units stored inside the cask are damaged either by the impact or by the fire and that those fission products are available for release. Of the available fission products, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids are released to the environment. Also, 10 percent of the original corrosion products from the fuel units are released from the cask to the atmosphere. The source term for this accident is shown in Table 5.15-18. The probability of this accident, based on analyses of other facilities at the site (Flanagan 1994), is small and assumed to be less than 1×10^{-6} per year.

5.15.4.1.6 Airplane Crash into Dry Cell Facility—The airplane crash into the dry cell facility accident that has been postulated to occur at the Naval Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the canning and characterization cell accident for the new Centralization Alternative facility at the ORR. This accident is initiated by an airplane crash into the dry cell facility. The accident was postulated to cause significant damage to the building, resulting in the loss of containment and filtered exhaust

Table 5.15-17. Estimated radionuclide releases for a wind-driven missile impact into a storage cask at ORR.[a]

Radionuclide	Release (Ci)
Cobalt-60	9.6×10^{-2}
Iron-55	1.8×10^{-1}
Cobalt-58	3.5×10^{-2}
Manganese-54	6.0×10^{-3}
Iron-59	5.1×10^{-4}

a. Source: See Section F.1.4.2.2.1, Appendix D to Volume 1.

Table 5.15-18. Estimated radionuclide releases for an airplane crash into dry storage facility at ORR.[a]

Radionuclide	Release (Ci)
Cesium-134	2.6×10^{1}
Cesium-137	3.6×10^{1}
Plutonium-238	5.9×10^{-2}
Barium-137m	3.1×10^{0}
Strontium-90	3.1×10^{0}
Cerium-144	7.2×10^{0}
Niobium-95	4.4×10^{0}
Yttrium-90	3.1×10^{0}
Ruthenium-106	6.1×10^{-1}

a. Source: See Section F.1.4.2.2.2, Appendix D to Volume 1.

systems. The fuel units inside the dry cell could also be damaged due to mechanical impacts and potential fire. The mechanical impact also could result in the release of corrosion products to the environment. For this accident scenario, 1 percent of the fuel units stored inside of the dry cell are assumed to be damaged by either the impact or resultant fire and those fission products would be available for release. Of the fission products available for release, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids could be released to the environment. Ten percent of the available corrosion products could be released to the environment. The source term for this accident is shown in Table 5.15-19. The probability of this accident is estimated to be less than 1×10^{-6} per year.

5.15.4.1.7 Airplane Crash into Water Pool—The airplane crash into the SNF water pool accident that has been postulated to occur at the Naval Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the SNF water pool accident for the new Centralization Alternative facility at the ORR. This externally initiated accident occurs when an airplane crashes into an SNF water pool and damages the fuel units stored there. Fission products and corrosion products are released from the fuel units into the water pool but the pool water is not released to the environment. The presence of the pool water results in a release only of gaseous fission products into the atmosphere. In this accident scenario, 1 percent of all the fuel units stored inside the pool were postulated to be damaged and those fission products are available for release. Of the available fission products, 100 percent of the noble gases and 25 percent of the halogens are released to the pool water. Due to the presence of pool water, there is a reduction of the halogen release by a factor of 10 prior to release into the atmosphere. The source term for this accident is shown in Table 5.15-20. The probability of this accident is estimated to be less than 1×10^{-6} per year.

5.15.4.1.8 Integration of Existing Facilities— Existing SNF management facilities will be integrated into the Centralization, Regionalization, and Planning Basis Alternative SNF storage functions until the existing ORR operating reactors are shutdown. The accident consequences postulated for the No Action Alternative in subsection 5.15.3 can occur as long as the High Flux Isotope Reactor is operational. After the High Flux Isotope Reactor is no longer operational, the accident consequence will decrease as the spent reactor cores, stored in the pool, age. The reference design basis accident frequency of occurrence and risk will be reduced because refueling operations have ceased and requirements for movement of the dam are reduced. Since the beyond design accident is initiated by natural phenomenon (i.e., tornado), the

Table 5.15-19. Estimated radionuclide releases for an airplane crash into dry cell facility at ORR.[a]

Radionuclide	Release (Ci)
Cesium-134	4.5×10^{1}
Cesium-137	6.2×10^{1}
Plutonium-238	1.0×10^{-1}
Barium-137m	5.4×10^{0}
Strontium-90	5.5×10^{0}
Cerium-144	1.3×10^{1}
Niobium-95	7.7×10^{0}
Yttrium-90	5.5×10^{0}
Ruthenium-106	1.1×10^{0}

a. Source: See Section F.1.4.2.3.3, Appendix D to Volume 1.

Table 5.15-20. Estimated radionuclide releases for an airplane crash into an SNF water pool at ORR.[a]

Radionuclide	Release (Ci)
Iodine-129	7.6×10^{-4}
Iodine-131	1.6×10^{-2}
Hydrogen-3 (Tritium)	4.3×10^{2}

a. Source: See Section F.1.4.2.1.4, Appendix D to Volume 1.

beyond design basis accident frequency of occurrence will remain the same as long as spent High Flux Isotope Reactor cores remain in the spent fuel pool area.

5.15.4.2 Nonradiological Hazards. The two bounding accidents involving nonradiological hazards are a chemical spill and fire and a diesel fuel fire. Both of these accidents are associated with the Expended Core Facility operations and the accident frequencies and impacts are addressed in Volume 1, Appendix D. The analyses of these accidents considered the impacts to workers on the site as well as to the offsite population. The impacts were measured in terms of potential health effects due to exposure to toxic chemicals released during these accidents. Since the Expended Core Facility at this site will be a new design and construction, it will incorporate all applicable standards and regulations and therefore limit the potential exposures to the workers and the public in the event of an accident.

5.15.4.3 Secondary Impacts. In the event of an accidental release of radioactive substances, there is a potential for secondary impacts to cultural resources, endangered species, water resources, public and agricultural land use, the ecology in the vicinity of the accident, national defense, and local economics. Figure 5.15-1 illustrates the radiological impacts to the environment in the event of a severe accident at a new SNF management facility and the release of radioactive material with 50 percent meteorology. The accident chosen for this purpose is an airplane crash into the Centralization Alternative canning and characterization (dry) cell. Figure 5.15-1 shows several isodose lines ranging from 870 millirem per year down to 87 millirem per year. The solid line represents the site boundary, and it can be seen from the figure that some doses exceeding background would exist outside the site boundary.

Table 5.15-21 presents a summary of the postulated severe accident secondary impacts on the environment, economy, and national defense. The evaluation was performed using 50 percent meteorology.

5.15.5 Decentralization Alternative

The Decentralization Alternative is not applicable for the ORR.

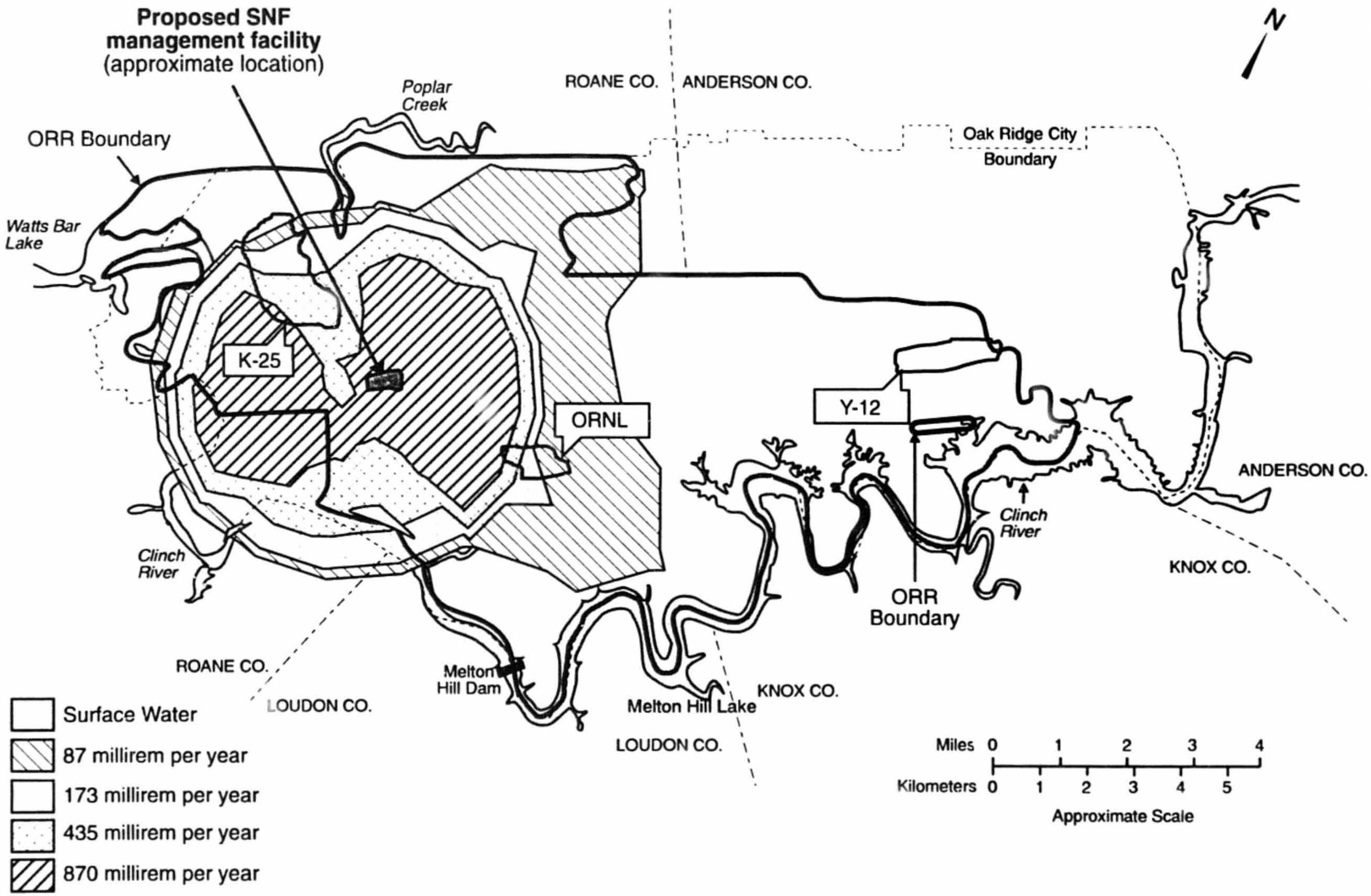

Figure 5.15-1. Isodose lines for an airplane crash into dry cell accident with 50 percent meteorology at Oak Ridge Reservation.

Table 5.15-21. Secondary impacts of Centralization Alternative accidents at the ORR.

Environmental or social factor	Impact
Land use	Yes. Major portions of the ORR, including the ORNL and K-25 areas, will be contaminated. Offsite contamination will occur. Industrial, residential, forest, and agricultural areas will be contaminated.
Cultural resources	Yes. Archaeological sites, cemeteries, and historic sites will be contaminated.
Aesthetic and scenic resources	Possible impact. Scenic public viewing areas are within 2 miles of the ORR border.
Water resources	Yes. The Clinch River will be contaminated. It is used for industrial and public water supplies, navigation, fishing, boating, and swimming.
Ecological resources	Possible impact. Many endangered or threatened plants and animals are potentially on or near the ORR.
Treaty rights	No impact. There are no ORR areas subject to Native American Treaty rights.
National defense	Possible impact. With the 50 percent meteorology, the area of contamination does not envelop U.S. military facilities or the Y-12 area. However, with the 95 percent meteorology, the Y-12 area will be contaminated.
Economic impacts	Yes. Offsite contamination will occur. Industrial, residential, forrest, and agricultural areas will be contaminated. Major portions of the ORR will be contaminated. The accident consequences may require the evacuation and cleanup of onsite facilities, including but not limited to the ORNL and K-25 areas, and adjacent residential, industrial, forest, and agricultural areas. The Clinch River will be contaminated. The associated industrial and residential water supplies will be contaminated. The commercial and recreational fishing industries may be impacted.

5.15.6 1992/1993 Planning Basis Alternative

The facility accident consequences and risks for the ORR No Action Alternative envelop the facility accident consequences and risks for the 1992/1993 Planning Basis Alternative.

5.15.7 Regionalization Alternative

Under the Regionalization Alternative, new facilities will be constructed and operated for SNF. Details for the new facilities needed have not been defined, but it is reasonable to expect that they will be similar to but with less storage requirements than those needed for the Centralization Alternative. Due to smaller throughput and storage requirements, the potential for accidents (i.e., probability of occurrence) will be similar to but less than those described for the Centralization Alternative. The accident consequences will be similar for both alternatives. Consequently, it is reasonable to assume that the accident consequences and risks described for the Centralization Alternative envelop the Regionalization Alternative.

5.15.8 Emergency Preparedness and Plans

The DOE has issued a series of Orders specifying the requirements for emergency preparedness (DOE 5500.1A, DOE 5500.2A, DOE 5500.3, draft DOE 5500.3A, DOE 5500.4, and DOE 5500.9), and each DOE site has established an emergency management program. These programs are developed and maintained to ensure adequate response for most accident conditions and to provide the framework to readily extend response efforts for accidents not specifically considered. The emergency management program incorporates activities associated with planning, preparedness, and response.

Officials at each DOE site have specified the emergency preparedness requirements for the DOE facilities under their jurisdiction in a manner consistent with the relevant DOE Orders. All existing facilities have emergency plans and procedures that either implement the DOE and site requirements or are integrated with the site planning.

DOE-Oak Ridge Operations has overall responsibility at the plant and laboratory sites for emergency response. However, primary authority for event response has been delegated to Martin Marietta Energy Systems, Inc., DOE's operating contractor. Although their primary responsibility is onsite, they have agreed to provide offsite assistance if requested under the terms of existing mutual aid agreements or Martin Marietta policies. If a hazardous materials event occurs at a DOE-Oak Ridge Operations facility, the Governor of Tennessee is responsible for the State's response efforts. The Governor's Executive Order No. 4 establishes the Tennessee Emergency Management Agency as the agency given responsibility for coordinating state emergency services. If a hazardous materials accident at DOE-Oak Ridge Operations facilities is beyond the capability of the local government, and assistance is requested, the Tennessee Emergency Management Agency Director may direct that assistance from state agencies be provided to local governments. To accomplish this task and ensure prompt initiation of emergency response actions, the Director may cause the State Emergency Operations Center and Field Coordination Center as well as any local Emergency Operations Center to be activated.

5.16 Cumulative Impacts and Impacts From Connected or Similar Actions

The ORR already contains several major DOE and non-DOE facilities, unrelated to SNF, that would continue to operate throughout the operating life of the proposed SNF management facilities. A number of offsite industrial and research facilities in surrounding areas would also continue to operate throughout this period. The activities associated with these existing facilities produce environmental consequences that have been included in the baseline environmental conditions (Chapter 4) against which Sections 5.1 through 5.15 have assessed the environmental consequences of the Centralization and Regionalization alternatives. This section uses the environmental baseline conditions presented in Chapter 4 to assess potential cumulative impacts from the proposed SNF management facilities, if constructed at the ORR, plus other reasonably foreseeable activities planned by government agencies or private concerns for areas on or near the ORR.

In addition to the proposed SNF management facilities, reasonably foreseeable activities considered in this cumulative impact assessment include the proposed Expended Core Facility, proposed hazardous waste remediation activities on the ORR, and activities proposed in the present Five-Year Plan for the ORR. Major programmatic initiatives planned for the ORR in the Five-Year Plan (MMES 1994a) consist of constructing the following: the proposed Advanced Neutron Source Facility; the proposed Uranium-Atomic Vapor Laser Isotope Separation Facility; facilities proposed for construction as a part of Complex-21; proposed low-level waste disposal

facilities; the proposed Mixed Waste Treatment Facility; the proposed Environmental, Life, and Social Sciences Complex; the proposed Materials, Science, and Engineering Complex; and the proposed Solid Waste Storage Area-7. Several minor construction projects such as the refurbishment or expansion of existing facilities, widening of roadways, and installation of utilities are also included in the Five-Year Plan.

The ORR is part of the City of Oak Ridge, which also includes an urban area to the north of the ORR and several industrial areas in various locations around the perimeter of the ORR. Additional construction and expanded operational activities is anticipated in these industrial areas. For example, the Scientific Ecology Group, a private business in the Bear Creek Industrial Park on Bear Creek Road west of the ORR, is considering expanding its operations and is presently constructing a second radioactive waste incinerator. The City of Oak Ridge Comprehensive Plan encourages further development of several presently undeveloped lots in several industrial parks (City of Oak Ridge 1989). The Comprehensive Plan also anticipates additional residential and commercial development in the City. The City of Oak Ridge is presently proposing construction of a golf course and residential development on approximately 700 acres (2.8 square kilometers) east of the ORR.

The following cumulative impacts analysis considers in detail the potential incremental effects from the proposed SNF management facilities; the proposed Expended Core Facility; and the proposed Advanced Neutron Source facility. Adequate information is not available to consider in detail the other proposed Five-Year Plan activities or the proposed activities for areas in the City of Oak Ridge outside of the ORR. The potential incremental impacts from these activities are therefore assessed in a more qualitative manner.

5.16.1 Centralization Alternative

Separate analyses of potential cumulative impacts from the Centralization Alternative to each of the environmental resources addressed in Chapter 5 are provided below.

5.16.1.1 Land Use. Construction of the proposed SNF management facilities would require the dedication of 90 acres (0.36 square kilometer) of undeveloped land on Bear Creek Road in the western part of the ORR. Construction of the proposed Expended Core Facility would require the dedication of an additional 30 acres (0.12 square kilometer) of undeveloped land on the ORR. Construction of the proposed Advanced Neutron Source facilities would require the dedication of an additional 75 to 115 acres (0.30 to 0.46 square kilometer) of land on the ORR (MMES 1992c). The cumulative land area dedicated to these three projects would total as much as 235 acres (0.95 square kilometer), which represents only about 1 percent of the roughly 20,600 acres (83 square kilometers) of undeveloped land remaining on the 34,667-acre (140 square kilometer) ORR. Additional unspecified areas of undeveloped land, generally parcels of under 100 acres (0.40 square kilometer), would have to be dedicated to some of the activities proposed in the Five-Year Plan. Many of these proposed activities do not require the dedication of undeveloped land. Additional undeveloped land on the ORR might have to be dedicated to the other planned activities, but their land requirements have not yet been quantified.

Although large areas of undeveloped land remain both on the ORR and in the City of Oak Ridge, much of this land is steep or otherwise has constraints that limit its future development potential. The City of Oak Ridge indicates in its Comprehensive Plan that it seeks to have additional ORR land declared excess by the DOE and made available for urban expansion by the City (City of Oak Ridge 1989). Demand for buildable land on the ORR by the City of Oak Ridge represents another cumulative demand for ORR land. The site of the proposed residential development and golf course east of the ORR is land recently sold by the DOE to the City of Oak Ridge since adoption of the Comprehensive Plan.

5.16.1.2 Occupational and Public Health. The annual collective effective dose equivalent from the existing ORR facilities to the population within 50 miles (80 kilometers) of the ORR is 52 person-rem (MMES 1994a). Added to this baseline, operation of the proposed SNF management facilities might contribute an additional 5 person-rem, and operation of the proposed Advanced Neutron Source facilities might contribute an additional 4.3 person-rem (MMES 1992c), resulting in a cumulative effective dose of 61 person-rem to the population within 50 miles of the ORR.

The annual collective effective dose equivalent from the existing ORR facilities to a potential maximally exposed individual at the site boundary is 3.3 millirem per year. Operation of the proposed SNF management facilities might contribute an additional 6.2 millirem per year, resulting in a cumulative annual dose of 9.5 millirem per year to this maximally exposed individual.

The total annual baseline worker dose seen from normal ORR operations is about 48 person-rem. The total annual SNF management facility worker dose is expected to be roughly 32 person-rem. Hence, the cumulative annual dose might be 80 person-rem.

Over the planned 40-year operational lifetime of the SNF management facility, a total population dose of roughly 2,500 person-rem will be observed from continuous operation of the existing ORR facilities and the SNF management facility. This equates to a total health detriment (the summated risk of fatal cancer, nonfatal cancer, and genetic effects) of 1.8 over the 40-year span. For the maximally exposed individual, a total dose of 380 millirem will be observed over the 40-year period, which equates to a total detriment of 2.8×10^{-4}. For the SNF management worker, a total dose of 3,200 person-rem will be observed over the 40-year span; this corresponds to a total health detriment of 1.8.

Additional radiological impacts are not expected from operation of the proposed Expended Core Facility. Analysis has shown that the dose to all individuals considered (workers and offsite individuals) from Oak Ridge Expended Core Facility operations might be much less than 1 millirem per year.

5.16.1.3 Noise. Cumulative increases in noise levels from the proposed SNF management facilities, the proposed Expended Core Facility, and the proposed Advanced Neutron Source facilities would be limited to temporary, minor construction noise and small increases in traffic noise occurring along various access routes to the ORR due to increases in employment. This increase is not expected to result in any increased annoyance to the public. Noise levels from other planned activities have not yet been determined. Each would, at a minimum, involve temporary periods of construction noise, but information on operational noise is not available.

5.16.1.4 Groundwater and Surface Water Resources. Operation of the proposed SNF management facilities would require the withdrawal of an estimated 4 million gallons per year (15 million liters per year) of groundwater. Operation of the proposed Expended Core Facility would require the withdrawal of an estimated additional 2 million gallons per year (8 million liters per year). Although the specific water demands of the proposed Advanced Neutron Source facility and other proposed activities are not known, the combined water demands would likely represent a small percentage of the total average discharge of the Clinch River, as measured at Melton Hill Dam, of 5,300 cubic feet per second (150 cubic meters per second).

Discharges of wastewater from the SNF management facilities would increase the flow of Grassy Creek by an estimated average of less than 1 percent. Discharge points would be selected in accordance with permit requirements to minimize impacts to surface water resources. The sanitary wastewater and cooling water from the Advanced Neutron Source facility would be discharged to separate streams and therefore would not contribute to cumulative impacts to Grassy Creek. Discharges from other planned facilities have not yet been designed. There are no expected cumulative impacts to groundwater quality and quantity.

5.16.1.5 Biotic Resources. Construction of the proposed SNF management facilities would require the disturbance of approximately 90 acres (0.36 square kilometer) of mostly forested terrestrial habitat, construction of the proposed Expended Core Facility would require the disturbance of an additional 30 acres (0.12 square kilometer), and construction of the proposed Advanced Neutron Source facilities would require the disturbance of an additional 75 to 115 acres (0.30 to 0.46 square kilometer). This would result in a combined conversion of as much as 235 acres (0.94 square kilometer) of forested habitat to developed uses. Additional areas of forested habitat on the ORR would be lost during construction of activities proposed in the Five-Year Plan. Additionally, losses of similar forested habitat off of the ORR are anticipated due to future construction in the City of Oak Ridge. For example, construction of the proposed golf course and residential development east of the ORR by the City of Oak Ridge would result in the conversion of several hundred acres of forested habitat to structures and lawns.

The total losses would represent only a small percentage of the total forested area on the ORR and in the surrounding vicinity. However, the several scattered areas of habitat disturbance planned for the ORR, including that associated with the SNF management facilities, would increase fragmentation of the relatively contiguous forest cover over much of the ORR. This fragmentation could affect the suitability of the forested habitat on the ORR for several species.

5.16.1.6 Air Resources. The potential cumulative air emissions from the proposed SNF management facility, Expended Core Facility, and Advanced Neutron Source facilities would not result in an exceedance of the National Ambient Air Quality Standards or Tennessee state

criteria. Also, there would be no exceedance of Federal National Emissions Standards for Hazardous Air Pollutants or DOE radiological standards. Air emission data for the other planned activities (Five-Year Plan or offsite) are not available.

5.16.1.7 Socioeconomics. Operation of the proposed SNF management facilities might generate up to 800 new jobs during the year 2005. Operation of the proposed Expended Core Facility might generate up to 562 additional jobs during that year, resulting in a combined increase of up to 1,362 new jobs. The 16,980 jobs presently forecasted for the ORR in the year 2005 would be increased by 8 percent, to as much as 18,342 jobs. The 360,000 jobs presently forecasted for the surrounding area in the year 2005 might be increased by less than 1 percent, to as much as 361,352 jobs. Additional employment increases could also result from the proposed Advanced Neutron Source facility project, activities proposed in the Five-Year Plan, and new offsite activities, but specific estimates are not available.

The proposed SNF management facilities could cause cumulative growth-inducing effects when coupled with the proposed Advanced Neutron Source facilities or with other planned activities on the ORR. Previous actions at the ORR have had a modest effect on long-term growth and productivity in Knox County and Loudon County, but they did not have a greater effect on long-term growth and productivity in Anderson County and Roane County.

5.16.1.8 Transportation. For transportation, minor levels of service changes might occur due to employment increases associated with the proposed SNF management facilities, the proposed Expended Core Facility, the proposed Advanced Neutron Source facility, some of the proposed onsite activities in the Five-Year Plan, and some of the proposed offsite activities. Maps included in the Five-Year Plan show several road improvements on the ORR to accommodate presently projected regional traffic increases.

5.16.1.9 Waste Management. Operation of the proposed SNF management facilities would generate an estimated 203 cubic meters per year of low-level waste and an estimated 16 cubic meters per year of transuranic waste. Operation of the proposed Expended Core Facility would generate an additional 425 cubic meters of low-level waste (for a combined total by both facilities of 628 cubic meters) but would not generate any additional transuranic waste. No other radioactive waste, including high-level waste or mixed waste, would be generated by either facility. Although it is known that the proposed Advanced Neutron Source facility would generate low-level waste, comparable quantitative data are not available for it or for offsite activities, or for activities proposed in the Five-Year Plan. All wastes generated by the proposed SNF management facilities and other planned activities on the ORR would be treated and disposed of in accordance with all applicable Federal and state regulations.

5.16.1.10 Other Resources. The absence of impacts, or the potential for very minimal impacts, from the proposed SNF management facilities to cultural resources, aesthetic and scenic resources, utilities, and geologic resources ensures that their potential contribution to cumulative impacts affecting these resources would be negligible. No further analysis is necessary.

5.16.2 Regionalization Alternative

The Regionalization Alternative would have similar or fewer cumulative impacts than the Centralization Alternative. Generally, the alternative requires less construction and smaller scale operations, and the potential for cumulative impacts is therefore less.

5.17. Adverse Environmental Effects That Cannot Be Avoided

5.17.1 Overview

This section discusses potentially unavoidable adverse impacts to the environment resulting from construction and operation of the proposed spent nuclear fuel (SNF) management facilities at the Oak Ridge Reservation (ORR) under the Centralization and Regionalization Alternatives. Unavoidable adverse impacts are impacts that cannot be mitigated by changes in project design, operation, construction, or by other measures.

5.17.2 Centralization Alternative

Operation of the proposed SNF facilities at the ORR under the Centralization Alternative would increase the radiation dose rate to the maximally exposed individual by 6.2 millirem per year, resulting in a 34 percent increase in cancer risk to this individual from ORR operations. These cancer risks still would be minimal. The number of fatal cancers resulting from 1 year of operations on the ORR from all sources (including baseline and the SNF facilities) would be

3.0×10^{-2}, the number of nonfatal cancers per year would be 5.9×10^{-3}, and the number of genetic effects per year would be 7.7×10^{-3}.

Construction of the proposed SNF management facilities would require the disturbance of approximately 90 acres (0.36 square kilometer) of mostly forested undeveloped land and the long-term dedication of approximately 85 acres (0.34 square kilometer) of land. Although this represents less than 1 percent of the undeveloped land on ORR, it would eliminate potential foraging and nesting habitat and would destroy plant species in the area. It would also require the dedication of a reasonably level land parcel that could have otherwise accommodated other construction projects.

The potential impacts from the Centralization Alternative to the other environmental resources discussed in Chapter 5 are not unavoidable adverse impacts.

5.17.3 Regionalization Alternative

Potential unavoidable adverse impacts associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. The extent of the impacts could be less due to the reduced land requirements, reduced extent of construction disturbance, and reduced scale of operations.

5.18 Relationship Between Short-Term Use of the Environment and the Maintenance of Long-Term Productivity

Implementation of any of the SNF management alternatives would cause some adverse impacts to the environment and permanently commit certain resources. These resources include use of the environment and those associated with construction and operation of the SNF management facilities.

The proposed alternatives for SNF management would require the short-term use of resources including energy, construction materials, and labor in order to achieve the objective of safety managing SNF to minimize the risk to workers, the public, and the environment.

The premature shutdown of research reactors due to a lack of sufficient SNF interim storage space under the No Action Alternative could have an impact upon the ORR regional communities. The ORR High Flux Isotope Reactor is an important source of radiopharmaceuticals. The reactors are unique research and training facilities for researchers and students in many fields of research and development: materials science, environmental science, physics, biology, and electronics.

Development of new SNF interim management facilities would commit lands to those uses from the time of construction through the cessation of operations, at which time the facilities could be converted to other uses or decontaminated, decommissioned, and the site restored to its original land use. Existing SNF management facilities could also be converted to other uses, or the lands could be restored following decommissioning.

5.19. Irreversible and Irretrievable Commitments of Resources

5.19.1 Overview

This section discusses the irreversible and irretrievable commitments of resources resulting from the use of materials that cannot be recovered or recycled, or that must be consumed or reduced to irrecoverable forms.

5.19.2 Centralization Alternative

Construction and operation of spent nuclear fuel (SNF) management facilities under the Centralization Alternative would require commitments of electrical energy, fuel, concrete, steel, sand, gravel, and miscellaneous chemicals. Most of the water that would be withdrawn from the Clinch River to operate the SNF management facilities would be returned to surface water in the Clinch River watershed, although some evaporative losses would be unavoidable. The land dedicated to the SNF management facilities could become available for other urban uses following closure and decommissioning. However, the soils on the site would have to be amended to support land uses such as agriculture, forestry, or wildlife management.

5.19.3 Regionalization Alternative

Irreversible and irretrievable commitments of resources associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. However, the extent of these resource commitments could be less due to the reduced land requirements and reduced scale of operations.

5.20 Potential and Mitigation Measures

5.20.1 Pollution Prevention

The DOE Oak Ridge Field Office established a Waste Minimization and Pollution Prevention Awareness Plan to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at Oak Ridge. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All contractors and users that exceed the EPA criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs. Contractor programs ensure that waste minimization activities are in accordance with Federal, state, and local environmental laws and regulations, and DOE Orders.

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of waste generated, and implementation of recycling programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor has been established to coordinate waste minimization and pollution awareness activities.

5.20.2 Potential Mitigation Measures

Potential impact avoidance and mitigation measures are addressed in Chapter 5, Sections 1 through 15 as appropriate.

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7.0 ABBREVIATIONS AND ACRONYMS

°C	degrees Celsius
CFR	Code of Federal Regulations
Ci	curie(s)
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EIS	environmental impact statement
ECF	Expended Core Facility
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
g	gram
gal	gallon(s)
hr	hour
INEL	Idaho National Engineering Laboratory
kg	kilogram
km	kilometer
kv	kilovolt
ℓ	liter
m	meter
m^3	cubic meter
mi	mile
mi^2	square mile
min	minute
mph	miles per hour
mR	milliroentgen
mrem	millirem
MTHM	metric tons of heavy metal
MW	Megawatt
nCi	nanocurie
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission

NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
pCi	picocurie(s)
PEIS	Programmatic Environmental Impact Statement
PM^{10}	particulate matter less than 10 microns in diameter
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
SNF	spent nuclear fuel
SRS	Savannah River Site
TVA	Tennessee Valley Authority
μg	micrograms
USGS	U.S. Geological Survey
yr	year

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